The University of Georgia
College of Agricultural and Environmental Sciences

Special Publication #95
July 1999

22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture

PROCEEDINGS

July 6 - 8, 1999

Tifton, Georgia

Proceedings of the

22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture

Georgia Agricultural Experiment Stations Special Publication 95

July 6 - 8, 1999
Tifton, Georgia

Edited by
J.E. Hook

National Environmentally Sound Production Agriculture Laboratory
The University of Georgia
College of Agricultural & Environmental Sciences
Tifton, Georgia U.S.A.

Hook, James E. (editor). 1947-
Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.

1999
Printed in the United States of America

This book was published by the Georgia Agricultural Experiment Stations, The University of Georgia, Athens, Georgia 30602, with partial funding provided by J. H. Harrison Research Foundation.

Foreword

The agriculture production regions of the southern United States are highly diverse in their crop systems and soil resources. Cropping systems include sub-tropical fruit, vegetable, and sugar cane systems, thermic zone peanut, cotton, tobacco, and rice crops, as well as more the temperate climate corn, soybean and wheat crops. Soils include highly eroded Piedmont and Mississippi terraces, poorly drained Delta and Flatwoods, high shrink/swell clays, deep, rapidly permeable sands, and dense, easily compacted Coastal Plain upland soils. Few rules of production are applicable throughout the region, and production practices deemed appropriate elsewhere in the United States are often inappropriate in the South.

The climate of the southeast serves to make it an area of near year-round production. The long-growing seasons create problems for conservation tillage, but also offer it unique solutions. In the mild fall and winter periods, insect and disease pests survive and even thrive ready to take on next year's crops. However, insect predators also survive, and, with appropriate management to foster their survival, these natural allies can be dependable. Weeds, likewise survive and grow throughout the non-crop periods. New herbicides help with their control, but the warm climate that supports the weeds can also be used to produce a weed-chocking cover crop that provides the added benefit of uniform surface protection against erosion. Humid and warm conditions of the growing season rapidly break down organic matter and crop residues making long-term buildup of humus nearly impossible. However, that rapid decomposition releases nutrients to the actively growing crop and removes straw and crop residues that otherwise might have interfered with harvest of the cotton and peanut crops.

This series of Southern Conservation Tillage Conferences has been held for the past 22 years as scientists, extension specialists, conservationists, and farmers grapple with the challenges of these unique growing conditions, crops and soils. Conservation tillage has progressed more slowly in the South than in other regions. There are many reasons for this – attempts to bring inappropriate technologies and practices from more temperate regions, earlier failures in reduced tillage before effective herbicides became available, unwillingness of farmers to risk changes in management on crops with subsidies, and general lack of federal and state research and extension for southern cropping systems are among them. The Southern Conservation Tillage Conferences bring focus to these problems and help identify effective solutions appropriate to the region.

The 1999 Conference held at the Rural Development Center in Tifton, Georgia, begins with a session on management challenges and opportunities in conservation tillage. These invited and volunteer papers focus on new opportunities for conservation tillage on crops that have been traditionally slow to change to conservation tillage. As we learn how cotton insect pest, peanut diseases, and vegetable weed and nematode problems can be minimized using conservation tillage, we see hope that conservation tillage will be adopted by farmers producing these crops.

The afternoon session turns to effective means of fostering adoption of conservation tillage by farmers. Farmer-to-farmer exchange of information continues to be the most effective means of spreading the experiences of successful farmers. That along with on-farm research and demonstration serve to adapt the general principals of conservation tillage to the specific soil, crop culture and climate of the area.

Farmers, along with logging operators hold and protect most of the open and natural spaces in the South. Having chosen to live in the more remote areas, they understand the relationships between healthy crop and timber operations and protection of wildlife and water and air quality. The continued pressure to increase farm production efficiency in the face of steady or falling commodity prices in order to make a reasonable family income has forced many to manage larger farms, buy larger equipment, and use more chemicals. However, many farmers see in this a decline in the basic productivity of their land and decline in the quality of their natural resources. Farmers who have switched all of their farming operations to conservation tillage principals enthusiastically report that they are once again seeing the wildlife populations increasing and using their fields for nesting and feeding. Many are also looking to wildlife management itself and an income generating part of their operations. The third session, a special evening session, of the Conference focuses on the use of conservation tillage principals fosters natural and managed wildlife populations.

We at the University of Georgia, the USDA ARS Research Units and NRCS in Georgia, along with the Georgia Conservation Tillage Alliance of farmers and the Georgia Department of Natural Resources appreciate this opportunity to host this annual conference and to facilitate adoption of conservation tillage practices.

This proceedings and the companion Southern Conservation Tillage Conference for Sustainable Agriculture are activities of the Southern Extension and Research Activity - Information Exchange Group 20 (SERA-IEG-20), which is sponsored by the Southern Association of Agricultural Experiment Station Directors, The Southern Association of Agricultural Extension Directors, the Cooperative State Research, Education and Extension Service (CSREES), and the participating State Universities and Federal Agencies.

This proceedings is the 22nd consecutive written proceedings published in conjunction with the annual conference. The body of knowledge on specifically southern conservation tillage research and extension in these proceedings is probably unequaled. With this 22nd Proceedings, we are beginning an additional effort to bring more complete papers to the series of proceedings. While the first part of the Proceedings includes the research summaries, interpretative summaries, annual reports and unreviewed preliminary papers like most of those published in previous years, the second section contains peer-reviewed manuscripts. While previous years proceedings usually included some complete papers that were not published in journals or other form, their authors never received recognition for these important, high quality papers. With the reviewed section, we hope to begin a volunteer contribution section of original research papers that have not been and will not be published elsewhere. Each manuscript was reviewed by two external reviewers, and authors were asked to make corrections as identified by those reviewers. Minor corrections and editorial changes were made by the editor directly. In a few cases papers not deemed complete or acceptable were moved to the non-reviewed portion of the Proceedings where their findings and results will still be available to the public and to abstracting services.

I would like to thank the following reviewers who provided this service in the very short time frame required to make publication deadlines so this Proceedings could be made available at the Conference itself:

John Baldwin
Phillip Bauer
Pat Bollich
Warren Busscher
Carl Crozier
Ford Eastin
Raymond Gallaher
Gary Gascho
John Grove
Joe Johnson
David Jordan
Terry Keisling
Dewey Lee
Robert McSorley
Sharad Phatak
Wayne Reeves
Harry Schomberg
Patricia Timper
Don Tyler
Ted Webster
David Wright

Conference Organizing Committee

Dr. James E. Hook
University of Georgia - NESPAL
Coastal Plain Experiment Station
P.O. Box 748
Tifton, GA 31793-0748
Phone: (912) 386-3182
Fax: (912) 386-7371
Email: jimhook@tifton.cpes.peachnet.edu

Dr. Harry Schomberg
USDA-ARS J. Phil Campbell, Sr.
Natural Resources Conservation Research Center
1420 Experiment Station Road
Watkinsville, GA 30677-2373
Phone: (706) 769-5631 x222
Fax: (706) 769-8962
Email: hschomberg@ag.gov

Lamar Black, Georgia Conservation Tillage Alliance
Dr. John Baldwin, Extension Agronomist, UGA
Dr. John Carroll, Warnell School of Forest Resources, UGA
Jimmy Dean, USDA Natural Resources Conservation Service, Athens, GA
Dr. Glen Harris, Extension Soil Scientist UGA
Dr. Sharad Phatak, Horticulture Research, UGA
Dr. Jean Steiner, USDA-ARS, Watkinsville, GA
Reggie Thackston, Georgia Department of Natural Resources Wildlife Resources Division

Co-Sponsors

UGA College of Agricultural and Environmental Sciences
National Environmentally Sound Production Agriculture Laboratory
Georgia Conservation Tillage Alliance
USDA Natural Resources Conservation Service
USDA Agricultural Research Service
UGA Daniel B. Warnell School of Forest Resources
Georgia Department of Natural Resources Wildlife Resources Division

Financial Supporters

Georgia Agricultural Commodity Commission for Corn
Georgia Soybean Association
Georgia Chapter of the Wildlife Society
Georgia Chapter of the Soil and Water Conservation Society
USDA-ARS J. Phil Campbell, Sr. Natural Resource Conservation Center
National Environmentally Sound Production Agricultural Laboratory
Monsanto
Novartis
Zenaca Agrochemicals
Rhone-Poulenc Ag Company
Kelly Manufacturing Company

Their support is gratefully acknowledged.

PROGRAM AND TABLE OF CONTENTS

Oral and Poster Presentations - **Presenting Author**

Presentation Time **7 July 1999**	*Oral and Poster Presentations* - **Presenting Author**	Summary Report Pg	Reviewed Paper Pg
	Session 3 - Managing for Wildlife with Conservation Tillage		
Moderator	**Mr. Reggie Thackston**		
7:00 PM	*Farming and Wildlife in the Southeast* - **John Carroll**	66	-
7:10 PM	*Benefits of No-till Soybean Production to Bobwhite Quail* - **Bill Palmer**	67	-
7:30 PM	*Benefits of Biotechnology and Conservation Tillage to Wildlife* - **John Anderson**	68	-
7:50 PM	*Transition Zone management: Fitting Wildlife into Modern Farming* - **John Carroll**	69	-
8:10 PM	*Technical Assistance and Farm Programs* - **Reggie Thackston**	-	-
Posters			
29	*Biotechnology and Conservation* - **John Anderson**	-	-
30	*Center Pivot Irrigation* - **Clay Sission**	-	-
31	*What are Georgia Hunting Leases Worth Today* - **Jeff Jackson**	70	-
32	*Managing Private Lands for Wildlife* - **Reggie Thackston**	71	-
33	*Quail Unlimited Conservation Efforts* - **Daniel Stillinger**	-	-
34	*NRCS Assists Wildlife Conservation Through Conservation Planning with Private Landowners* - **Louis Justice**	-	-
35	*The Effect of Habitat Manipulation on Insect Diversity and Bobwhite Quail Populations in a Cotton Production System* - **Randy Hudson**	72	-
36	*Effects of Clover Strip-cover Cropping of Cotton on Songbird Populations and Northern Bobwhite Brood Habitats* - **Sandy Cederbaum**	73	-

Thursday 8 July 1999	***Session 4 - Research and Farm Field Visits***
8:00 AM	*Coastal Plain Experiment Station Conservation Tillage Research* - **Glen Harris & John Baldwin**
10:30 AM	*Tift County Farm Field Visits* - **Mary Leidner & Reggie Thackston**
1:30 PM	*Kelly Manufacturing Corporation Farm* - **Tony Jackson & Charles Sumner**

PART 1

Abstracts,
Interpretative Summaries,
Annual Reports, and
Non-Reviewed Papers

INSECT MANAGEMENT AS A COMPONENT OF A SUSTAINABLE COTTON PRODUCTION SYSTEM

W. J. Lewis[1], S. C. Phatak[2], and Alton I. Walker[3]

AUTHORS: [1]Research Entomologist, USDA-ARS, Insect Biology and Population Management Research Laboratory, Tifton, GA, 31793; [2]Professor, Horticulture Department, University of Georgia, P. O. Box 748 Tifton, GA 31793; [3]Agricultural Consultant, 6319 Brown Road, Harlem, GA 30814.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Eradication of the boll weevil in the southeastern United States has provided a vastly improved opportunity for sustainable cotton production. In the absence of early season boll weevil treatment interventions, there is the opportunity to utilize cover crops and conservation tillage as a effective means of early season buildup of natural enemy/ pest balances for relay into cotton. Thereby, the practices of conservation tillage/ soil conservation can be integrated together for mutual benefit.

On-farm pilot initiatives were conducted in cooperation with several growers at varied locations in Georgia 1996-1998. The management practices studied were: 1) habitat management -- cover crops and conservation tillage; 2) minimal and least disruptive inputs -- fertilizers, pesticides, and fossil fuel; and 3) broad-based intervention decisions -- pesticide treatment decisions. Comprehensive sampling and analyses of included thorough soil properties, insect populations, plant growth/ damage, predation/parasitization, energy inputs, yields, and net profits.

The following general conclusions were made:

- In addition to long-term natural resource conservation benefits, sustainable versus conventional practices are competitive in terms of year-to-year profitability.
- There is a limited knowledge on various cover crop attributes and their management. There is a need for more knowledge relative to various cover crop options, attributes and management requirements.
- Perennial management systems do provide a balance of beneficial/pest insect populations.
- There is a need for improved methods to obtain reliable cotton crop stands with conservation tillage practices.
- There is a need for increased knowledge on potential benefits of wildlife and improved soil ecology.

OPPORTUNITIES FOR CONSERVATION TILLAGE IN VEGETABLE PRODUCTION

Sharad C. Phatak[1] and Rick Reed[2]

AUTHORS: [1]University of Georgia, P.O. Box 748, Tifton, GA 31794; [2]University of Georgia, Cooperative Extension Service, Douglas, GA 31533.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Conservation tillage plays an important role in reducing soil erosion and improving soil quality. Acreage under conservation till is rapidly increasing in recent years. USDA statistics indicates that over 100 million acres of farm land is now under conservation tillage. However, this substantial increase has made very little impact on the way growers produce vegetables. In the south, most vegetable production is still dependent upon high inputs and conventional tillage. There are number of reasons for lack interest in conservation tillage for vegetable production. Some of these reasons are:

- Lack of research on conservation tillage for vegetable production.
- Lack interest from vegetable researchers to work in this area.
- Too many crops, over forty vegetable crops are commercially grown in Georgia.
- It is difficult to take risks with ‘High Value Crops’ like vegetables.
- Research show that there is a yield reduction associated with conservation tillage in vegetables.
- Market windows require that crops be marketed during specific time.

Many growers who have switched to conservation tillage do not produce vegetables. But economic considerations are forcing them to look for alternative crops to maintain farming profitable. Some of these alternative crops are vegetables which remain profitable. Conversion from conventional tillage to conservation tillage saves $30 to $50 per acre. Not enough incentive to switch. Usual conservation tillage benefits like reduce erosion, improve soil quality, improve water holding capacity, etc. do not come with direct cost benefits. Only way to convince vegetable growers to show that it is a total system including cover crops, conservation tillage which will help them reduce tillage, fertilizer, and most pesticides. This will reduce off-farm inputs and thus. reduce production costs. Bottom line is the key. We have developed such systems in which conservation tillage is a key component.

PROGRESS OF RESEARCH

In 1985, we started our research on evaluating cover crops to improve soil and reduce pest pressures. The first year of trials, we evaluated 20 cover crops. Cover crops were planted in November. These over-wintering cover crops were strip-killed with glyphosate and then tilled. In the spring, various vegetable crops were planted in these strip-tilled plots. These strips were 12 inches wide and placed 3 feet apart on a bed with a 6-foot center. Cover crops in the middle and side of the bed were alive at the time of planting vegetables. As the season progressed these cover crops died. Herbicides and fertilizer were used as needed. No insecticides, fungicide, or nematicides were used. To our surprise, we observed less than 1% damage from insect pests and essentially there were no foliar disease problems. We continued this work for another year with the same results. Based on the success of our trials we applied for a Southern Region IPM grant to study the “Effects of Cover Crops on Weeds, Insect Pests, Diseases, and Nematodes on Vegetables.” This research was funded for two years and was renewed for another two years. Four years of research involved 5 cover crops and fallow, followed by two double-crop vegetable rotations. During these six years the land was plowed in the fall before planting cover crops. Cover crops were planted every year. After 6 years of research with cover crops we learned that insect pests and foliar diseases were substantially reduced in a relay cropping system as outlined above. However seedling diseases and nematodes became a major problems in legume cover crops. We also observed similar problems on grower fields.

This ultimately convinced us to evaluate a conservation tillage system. Since 1991, a number of cover crops, followed by vegetable crops and agronomic crops have been evaluated. Since 1993, many of these rotations have been used by growers to reduce pest pressures and reduce pesticide use. These systems are environmentally friendly and economical feasible. Conservation tillage will improve soil quality and make it more productive and healthy.

Healthy (quality) soils, grow healthy crops. Healthy plants resist pest pressures more effectively. Excessive use of fertilizers and pesticides destroys the natural ecosystems and the plant’s natural defenses. To reduce pest pressures we need to work with nature and not try to control or destroy it.

HOW TO IMPROVE SOIL QUALITY, MAKE SOIL MORE PRODUCTIVE AND HEALTHY

The land which has been under trees and pastures for over 10 years, when brought into cultivation remains productive for 2-3 years. Bumper crops are raised in this newly opened soil with very little off-farm inputs in the beginning. As time goes by with more plowing and harrowing, organic matter is destroyed and higher off-farm inputs are needed to produce the same yields of crops. This increases production cost. This increase in off-farm inputs include substantial increases in pesticide use due to increased pest pressures.

Soil that has been under the cover of trees and pastures is not mechanically tilled which helps build organic matter which in turn improves soil structure and support high level of biological activity. This improves soil quality and productivity. Same results may be achieved by a shift in paradigm, that is by changing the way we till the soil. Adapt crop production to conservation tillage. By making this change growers will eliminate tillage operations which are detrimental to soil structure, soil organic matter, soil biological activity and indirectly soil productivity. These detrimental operation include plowing, disc harrowing, and use of rototillers.

CONSERVATION TILLAGE HOW-TO

Collect soil samples preferably in the fall. Get it tested. Apply all nutrients needed to bring levels to medium-high or higher. Adjust pH as needed. Lay-out beds. Plant selected over-wintering cover crops (small grains, legumes, etc.) during fall. In the spring, broadcast or strip kill cover crop mechanically or with herbicide. Cover crop residues and crop residues are left on the surface. Plant agronomic or vegetable crops. Crops raised under this system are not subjected to severe moisture and nutrient stresses and thus are healthy. These crops resist pest pressures better than conventionally grow crops. Conservation tillage system outlined above will help reduce pest pressure as presented.

Tillage

Successful conversion from conventional tillage requires proper planning and implementing those plans with precession. Many growers fail to plan ahead of time which ends up into an unsuccessful effort. How to plan and implement this conversion is briefly outlined above. Detailed information on successful planning and conversion to conservation tillage may be obtained from County Extension Service and Natural Resources Conservation Service.

Not-till delays vegetable harvest by two-three weeks and thus, strip-tilling is essential to harvest crops to coincide the market window.

Fertility

Conservation tillage help in reduction of nutrient losses due to erosion and leaching. Thus, it should be possible to maintain soil fertility by replacing nutrients removed by harvested crops. Our research and growers trials show that vegetable crops can be produced with reduced fertilizers in conservation tillage.

Weeds

Herbicides registered for use on vegetable are limited and thus, controlling weeds in vegetables in conventional production is difficult. It is even more difficult in vegetables grown in conservation tillage. Inadequate weed control reduce crop yields. It is possible to obtain excellent early season weed control in no-till system with rye or other cover crops with allelopathic ability. No-till delays harvests and is not a choice for vegetable growers with a limited market window. However. with proper planning growers may be able to obtain adequate weed control by utilizing following advantages derived from conservation tillage:

1. Reduced tillage and plowing leaves large number of weed seeds buried under.
2. Cover crop and crop residue form thick mulch which suppress weed germination.
3. Some cover crops like rye are allelopathic. Mulches of these crops are more effective in controlling weeds.

Insect Pests

Conservation tillage help provide habitat for beneficial insects and other beneficial organisms. It is however essential to develop planting schemes to provide year-round habitat for beneficials to derive maximum benefits.

1. Living, dead, and dying mulches provide habitat and food for beneficial.
2. Beneficial are in place on winter cover crops at the time of spring planting.

Diseases

It is difficult to explain as to why less diseases are observed on vegetables grown under conservation tillage.

1. Foliar diseases are substantially reduced in this system. No sandblasting, no injury to plants from cultivation and other effects on surface microflora.
2. Seedling diseases may be higher during the first year. However, incidence of soilborne diseases reduce drastically during succeeding years probably due to increase organic matter and increase beneficial soil

miroflora.

3. Reduction in viruses (e.g. tomato spotted wilt virus, squash mosiac, cucumber mosiac, etc.) May be due reduction in vector populations.

Nematodes

Conservation tillage also reduces nematode damage to vegetables. In some instances parasitic nematode population is reduced while in other situations damage reduction is without reduction in nematode populations.

1. Reduction in nematodes and/or nematode damage to crops probably due to increase in organic matter. It is possible to grow most vegetables in conservation tillage profitable by using 'Total System' as outlined above. Vegetable crops which have been raised with reduced inputs (fertilizers and pesticides) with cover crops and conservation tillage include, tomatoes, peppers, eggplants, cabbage, broccoli, watermelon, squash, cantaloupe, cucumber, beans, peas and okra. Most transplanted crops and large-seeded crops may be raised profitable using these systems. More research is needed with small-seeded crops which are direct seeded for example carrots, mustards, turnips etc.

A few growers have not only adapted these systems but improvised to make them profitable for the vegetable crops they are producing. More new growers are trying these systems. We are hopeful that more growers will see the value of these systems to make vegetable production more profitable and environmentally safe.

ACKNOWLEDGMENTS

We want to thank cooperation of Drs. Bugg,, Chalfant, Chandler and Gay during research phase of this program. Jimmy Hornbuckle, Tony Bateman, Ernest Cravey, Ron Dozier and Kate Bruson provided valuable technical support. Valuable participation and support of progressive growers namely, Tommie Dorminey, Wayne Fussell and Roscoe Meeks has been essential for the success of this project.

CONSERVATION TILLAGE IN IRRIGATED COASTAL PLAIN DOUBLE-CROP ROTATIONS

C. C. Dowler[1], J. E. Hook[2], S. H. Baker[3], G. J. Gascho[4], A. W. Johnson[5]

AUTHORS: [1]Research Agronomist (Retired) and [5]Supervisory Research Plant Pathologist, USDA-ARS Nematodes, Weeds and Crops Research Unit, P.O. Box 748, Tifton, GA 31793; [2,4]Professor and [3]Assistant Research Scientist (Emeritus), Crop and Soil Sciences Department, University of Georgia, P.O. Box 748, Tifton, GA 31793. [1]Corresponding Author, Clyde Dowler, Email: dowler@tifton.cpes.peachnet.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95, Athens, GA.

INTERPRETIVE SUMMARY

Various levels of conservation tillage (leaving some portion of the previous plant residue on the soil surface) are being studied and utilized for producing crops in the southeastern United States. Soil moisture is a critical factor in the sandy coastal plain soils. Supplemental irrigation is often needed to maintain consistent productivity. Research was extremely limited on studying the effects of various conservation tillage practices on crops grown under irrigation. We evaluated double cropping sequences of a small grain grown for grain and a row crop of cotton, peanut, or soybeans following small grain. Irrigation application technology was utilized as much as possible. Adequate soil moisture and establishing a good crop stand are keys to good productivity. In our studies, a good crop stand was generally obtained, because good soil moisture could be maintained by irrigation. All crops yielded more in moldboard plow tillage and least in no-till tillage. In many cases, yield of cotton, soybean, or peanut under strip tillage approached that of moldboard plow tillage. Growing cotton, peanut, or soybean for eleven years of strip tillage did not result in long-term yield reduction or pest management problems. Pest management was determined by scouting, which proved effective in all rotations. Weeds, insects, and diseases were no worse in conservation tillage than in moldboard plow tillage. This was the result of continual scouting. Under irrigation, long-term conservation tillage appears feasible.

See this full paper and its tables and figures in the Reviewed Papers Section of this Proceedings.

SOIL BIOLOGY UNDER CONSERVATION TILLAGE

Paul F. Hendrix[1]

AUTHOR: [1]Institute of Ecology and Department of Crop and Soil Sciences, University of Georgia, Athens, GA 30602. Email: phendrix@sparc.ecology.uga.edu.

REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTERPRETIVE SUMMARY

Soil biota comprise a wide array of organisms which spend all or part of their life cycle in soil. Taxonomically, they include hundreds of thousands of species representing 11 animal phyla and all known types of microorganisms; morphologically, they range in size from less than one micrometer (bacteria) to several centimeters in diameter and up to 1.5 m in length (the giant Australian earthworm). In most agricultural soils the diversity of soil biota is higher under conservation management than under intensive cultivation.

Soil biota influence soil processes through 1) effects on soil structure; 2) effects on organic matter dynamics and nutrient cycling; and 3) in the case of soil fauna, effects on microbial activity. Structural effects are most obvious from larger animals, such as earthworms and ants, and include casting which can enhance soil aggregation, and burrowing which can increase soil porosity, water infiltration and aeration; soil fungi and plant roots also contribute to aggregate and pore formation. Organic matter and nutrient transformations are carried out via enzymatic processes by soil microbes (principally bacteria and fungi), but are influenced by soil animals through fragmentation, redistribution and microbial inoculation of organic residues, and increased turnover of microbial biomass.

Tillage impacts soil biota 1) directly by changing the relative abundance and vertical distribution of organisms; and 2) indirectly by altering microhabitat conditions and the distribution and availability of organic matter. Compared to soil biota under no-tillage, those in plowed soils tend to be smaller in size, capable of rapid reproduction and dispersal, display a lower degree of food and habitat specificity and a higher metabolic rate. These differences in species composition may alter the trophic structure of detritus food webs. Data from sites on the Georgia Piedmont and elsewhere show that no-tillage management favors food webs dominated by fungi and fungal-feeding soil animals, and high abundances of earthworms. In contrast, food webs in plowed soils show greater importance of bacteria and bacterial-feeding fauna, such as protozoa and bacteriophagous nematodes, which colonize buried residues. As a consequence of these altered biotic communities, residue decomposition, organic matter mineralization, and nutrient release rates tend to be higher in plowed than in no-till soils.

The idea of soil biotic 'husbandry' offers interesting possibilities for soil management. Examples include 1) increasing soil biodiversity through reduced tillage, cover cropping, maintenance of surface residues, and/or addition of organic amendments; and 2) optimizing soil biological activity through residue management to accelerate or slow residue decomposition, or to enhance nutrient immobilization or mineralization.

PEANUT CULTIVAR RESPONSE WHEN PLANTED IN EITHER TWIN OR SINGLE ROW PATTERNS BY STRIP TILLAGE OR NO-TILLAGE METHODS

J. A. Baldwin[1], A. K. Culbreath[2], S. Jones[3]

AUTHORS:[1]Professor, Crop and Soil Sciences Department; [2]Professor, Plant Pathology Department, University of Georgia, CAES Tifton Campus, Post Office Box 1209, Tifton, GA 31794; [3]Superintendent, Southwest Georgia Branch Experiment Station, Plains, GA 31780. Corresponding author: J. A. Baldwin Email: jbaldwin@arches.uga.edu.

REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*, Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95, Athens, GA.

Abstract. The object of this experiment was to determine the response of peanut when planting in single or twin row patterns by strip tillage or no tillage methods. During 1997 and 1998 the peanut cultivars "Georgia Green" and "Georgia Runner" or "Georgia Green" and "Georgia Bold" (*Arachis hypogaea L.*) were planted in 9.5 or 9.0 inch twin row patterns versus 36 inch single rows at the same seeding rate (6 seed/foot singles or 3 seed/foot twins). The peanuts were planted into mowed cotton stubble without a cover crop by either strip tillage or no-tillage methods.

During 1997 there was no difference in grade (TSMK) or tomato spotted wilt incidence (TSWV) between strip tillage or no tillage. Georgia Green had significantly less TSWV than Georgia Runner. There was a significant yield increase for twin rows over single rows. In 1998, there was no response to tillage method or row pattern. Georgia Green did have significantly less TSWV than Georgia Bold. In both years, there was a trend toward higher yields with the twin row pattern and digging losses would attribute to the lack of response to the twin row patterns during 1998.

See this full paper and its tables and figures in the Reviewed Papers Section of the Proceedings.

EVALUATION OF TILLAGE SYSTEMS IN NORTH CAROLINA PEANUT PRODUCTION

A. J. Whitehead, Jr.[1], D. L. Jordan[2], P. D. Johnson[3], J. M. Williams[4], J. S. Barnes[5], C. R. Bogle[6], G. C. Naderman[7], and G. T. Roberson[7]

AUTHORS: [1] Associate Extension Agent, North Carolina Cooperative Extension Service, P. O. Box 37, Halifax, NC 27839. [2]Department of Crop Science, North Carolina State University, Box 7620, Raleigh, NC 27695. [3]County Director, North Carolina Cooperative Extension Service, P. O. Box 1030, Edenton, NC 27932. [4]Box 220, Peanut Belt Research Station, North Carolina Department of Agriculture and Consumer Services, Lewiston-Woodville, NC 27849. [5]Upper Coastal Plain Research Station, North Carolina Department of Agriculture and Consumer Services, Rt. 2 Box 400, Rocky Mount, NC 27801. [6]Department of Soil Science, Box 7619, North Carolina State University, Raleigh, NC 27695. [7]Department of Biological and Agricultural Engineering, Box 7625, Raleigh, NC 27695. [2]Corresponding Author David Jordon, Email: David_Jordon@ncus.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

RESEARCH QUESTION

Reduced tillage production is being viewed as a viable option by some peanut growers in the southern United States. However, peanut response to reduced-tillage practices has been inconsistent. Defining factors that affect response of peanut to varying tillage practices is important. The objectives of this research were do determine the effect of conventional and reduced tillage systems on peanut response to preplant fertilizer and mid-season gypsum applications.

LITERATURE SUMMARY

A variety of reduced tillage crop production systems are being evaluated in the southern United States. Although farmers who produce cotton and other row crops in reduced tillage systems would also like to produce peanut in this manner, they are reluctant to reduce or eliminate primary tillage for a variety of reasons. Moldboard plowing has been recommended for many years to reduce southern stem rot and other soil-borne diseases, to reduce weed populations, and to bury crop residue in an effort to prepare a clean and uniform seedbed that allows good seed placement. However, tillage practices are expensive and time consuming, and timing for tillage practices comes when growers are involved in many other farming operations. Research with reduced tillage systems in peanut have shown variable results. Research suggests that eliminating primary tillage practices such as disking or moldboard plowing can delay peanut maturity. Other research suggests that planting peanut into a killed cover crop with strip tillage equipment can lower insect infestations. The effect of tillage practices on disease reaction varies by pathogen and has not been conclusively determined. From an agronomic standpoint, fertilizer placement is important in maintaining yield and optimum market grades. Preplant fertilizer for peanut is often applied to the crop planted the year before peanut or it is incorporated throughout the soil profile using deep tillage in the fall or spring prior to planting peanut. Excessive amounts of potassium or magnesium can compete with absorption of calcium by developing pegs. Calcium is critical in kernel formation. Tillage systems that eliminate deep tillage such as chisel plowing or moldboard plowing make incorporation of fertilizer and lime throughout the soil profile more difficult. Additionally, existing residue my affect movement of supplemental calcium into the pegging zone. Research is needed to define how these factors affect peanut response to tillage systems.

STUDY DESCRIPTION

Field studies were conducted during 1997 and 1998 to compare pod yield, market grade, and gross economic value of peanut in conventional tillage systems compared with strip tillage systems. In one study, tillage treatments consisted of: 1) disk and bed; 2) disk, chisel plow, and bed; 3) disk, moldboard plow, and bed; 4) strip till into beds established the previous fall (stale seedbeds); 5) strip till into existing corn or cotton stubble; and 6) strip till into beds with a desiccated wheat cover crop. A PTO-driven Ferguson strip tillage implement was used at two locations. Subsoiling was included at one location. Also, a non-PTO-driven Ferguson strip tillage implement with in-row subsoiler and two crumblers was included at one location. Twelve to twenty inches of the row was tilled. In these experiments, preplant fertilizer [100 lb/acre potash or 150 lb/acre 5-10-10 (N, P_2O_5, K_2O)] was included as a treatment variable in each tillage system. In two experiments, fertilizer was applied in the spring prior to disk, chisel, and moldboard plow operations but following establishment of beds and the cover crop the previous fall. At the other location fertilizer was applied after moldboard plowing. Gypsum was applied uniformly over the entire test area at peanut pegging. In a separate study, peanut response to supplemental calcium (0, 300, and 600 lb/acre gypsum) was evaluated in conventional till, strip till (non-PTO-driven Ferguson strip tillage implement described previously), and no-till (culter only) systems. Plot size was 4 rows (36-inch spacing) by 50 feet in both studies.

APPLIED QUESTIONS

How does tillage affect peanut response to preplant fertilizer applications?

Peanut response to tillage varied among locations and years. However, tillage systems did not affect peanut response to preplant fertilizer placement. Tillage systems did affect peanut pod yield and gross value independent of preplant fertilizer. Yield and gross value were generally lower in reduced tillage systems compared with conventional tillage systems on a sandy clay loam soil. This soil is in the Roanoke soil series and has a distinct and deep clay layer 6 to 10 inches below the soil surface. In contrast, yield and gross value in reduced tillage systems equaled or exceeded that of conventional tillage systems on a sandy loam soil in the Norfolk soil series. Subsoiling was included in studies on sandy loam soils but not on the sandy clay loam soil. On the sandy clay loam soils, where reduced tillage systems were less effective, compacted soil may have adversely affected peanut growth and pod development. These soils often are not subsoiled because of a distinct clay layer below the sandy clay loam top soil. Bringing clay particles and clods to the soil surface would interfere with harvesting and digging efficiency. However, more vigorous tillage within the pegging zone and above the clay layer may be needed on these soils in order to obtain yields comparable to conventional tillage systems. Additional research is needed to address this subject. These data suggest that tillage does not affect peanut response to preplant fertilizer. However, fertilizer at higher rates may have a different affect.

How does tillage affect peanut response to gypsum applications?

In the gypsum study, interactions among tillage systems and gypsum rates were not significant. Pod yield and gross value in conventional tillage systems equalled or exceeded that in the no-till and strip till systems. Although peanut generally responded to gypsum, response was independent of tillage systems. This suggests that peanut response to gypsum is similar in conventional, strip till, and no-till systems.

RECOMMENDATIONS

These studies suggest that additional research is needed to further define variables that affect peanut response to tillage systems. Variability in response was noted among locations, soil characteristics, and tillage systems. In these studies preplant fertilizer did not affect peanut yield or gross value. However, higher rates of fertilizer may have a different affect. The impact of subsoiling on soils with substantial clay content should be addressed. Results from these studies also suggest that peanut response to gypsum is independent of tillage systems. Collectively, these studies suggest that reduced tillage systems are a viable alternative to conventional tillage systems in some situations. Because digging is required prior to harvest, and because soil characteristics greatly influence efficiency of digging, growers should experiment with tillage systems on a fraction of their acreage before wide-scale expansion.

See this full paper and its tables and figures in the Reviewed Papers Section of the Proceedings.

EFFECTS OF TILLAGE SYSTEMS ON PEANUT DISEASES, YIELD AND FUNGICIDE PERFORMANCE IN A PEANUT-COTTON ROTATION

T. B. Brenneman[1], S. H. Baker[2], W. C. Johnson III[3], A. W. Johnson[4], and D. R. Sumner[5]

AUTHORS: [1,2]Professor of Plant Pathology Department and Assistant Research Scientist (retired), Crop and Soil Sciences Department, University of Georgia, P.O Box 748, Tifton, GA, 31704; [3]Weed Scientist and [4]Supervisory Plant Pathologist, USDA-ARS Nematodes, Weeds and Crops Research Unit, P.O. Box 748, Tifton, GA 31793. Correspondings Author: Tim Brenneman, Email Arachis@tifton.cpes.peachnet.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95, Athens, GA.

INTERPRETIVE SUMMARY

Reduced tillage systems are rapidly gaining in popularity throughout the southeastern United States. The adoption of reduced tillage methods has been slower in peanuts than in other crops, but more farmers are utilizing this technology for peanuts. The need to start growing peanuts to sell at competitive world market prices has generated interest in reduced input production systems, and reduced tillage systems help some growers achieve that goal. The additional benefits for reduced soil erosion, improved water infiltration, and economics of time and labor make reduced tillage even more attractive, particularly in areas with highly erodible soils.

One of the factors that has limited the acceptance of reduced tillage for peanut production has been the belief that conventional deep turning was essential for disease control, particularly stem rot (white mold) caused by *Sclerotium rolfsii*. This disease has been a major production constraint for peanut producers in Georgia for many years and continues to be one of our most damaging diseases. Previous work has demonstrated the potential for organic matter near or at the soil surface to increase losses to stem rot. With few other options previously available to manage this widespread pathogen, deep turning the soil was considered a frontline of defense. The registration of several highly effective fungicides has greatly increased our ability to manage stem rot, but deep turning has persisted as the primary method of land preparation for peanuts in Georgia.

Crop rotation is also known to have dramatic effects on peanut productivity and disease levels. The rapid increase in cotton acres in Georgia during the 1990's has made it the most commonly rotated crop with peanut. This rotation is generally favorable for cotton production and for reducing nematode and stem rot levels in peanut, but there are concerns about Rhizoctonia limb rot. Cotton stalks are also persistent and contribute to higher levels of organic matter associated with cotton rotations.

In this study we evaluated peanut and cotton grown in alternating years from 1994-1998 using conventional deep turning, strip tillage in a rye stubble, and strip tillage in a stale seed bed consisting of the previous years crop stubble and weeds killed by herbicide. Split plots of peanut were treated or not treated with Moncut for control of soilborne peanut diseases. The field had high levels of stem rot with an incidence of up to 45% in nontreated plots. Moncut reduced stem rot incidence 70-80% and increased peanut yields up to 47%. The fungicide was equally effective in the conventional and reduced tillage plots. In the plots where Moncut was not sprayed, there were small differences in disease incidence in some years, but over the five years of the study stem rot levels were similar in all tillage treatments. Tomato Spotted Wilt Virus (TSWV) was a significant factor each year of the test. The conventional tillage plots had significantly higher incidence of this disease several years, thus verifying observations that reduced tillage fields had reduced damage from TSWV. This factor has since been incorporated into the Georgia TSWV Risk Index. Rhizoctonia limb rot was present only at low levels each year of the study and little was learned about the effects of tillage on this disease.

Crop yields were very similar among the three tillage treatments. There were no significant differences in peanut yields due to tillage in any year of the study. Average yields across years were 2842, 2995, and 2966 lb/A for the conventional tillage, strip till in rye, and strip till in a stale bed, respectively. Moncut consistently increased peanut yields with the greatest increase being 47%. Seed cotton yields showed some variation among tillages, but it was not consistent from year to year. Most years cotton yields were similar among tillage treatments averaging 1246, 1178, and 1202 lb/a for the conventional tillage, strip till in rye, and strip till in a stale bed.

Overall there were surprisingly few differences among tillage treatments in crop yield and disease levels, especially since there was a lot of stem rot present. Increased crop residues in this study did not increase diseases. Differences were observed among weed control programs. Reduced tillage systems required greater inputs of post-emergence herbicides and volunteer peanuts were a problem in reduced tillage cotton. Reduced tillage peanuts may have a place for more growers in the southeast. Further improvements in farm chemicals and other technologies may make it even more practical.

CROP SEQUENCE EFFECTS ON THE PROPERTIES OF A PALEUDALF UNDER CONTINUOUS NO-TILLAGE MANAGEMENT

J.H. Grove[1] and M. Díaz-Zorita

AUTHORS: [1]Department of Agronomy, University of Kentucky, N-122 Agriculture Science Center North, Lexington, KY 40546-0091; [2]INTA Gral. Villegas, CC 153 (6230) Gral. Villegas (BA), Argentina. Corresponding author John Grove, E-mail: jgrove@ca.uky.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95, Athens, GA.

INTRODUCTION

Weathered well-developed soils are common in the Southeastern region of the US. These soils usually have low organic matter contents and often are highly susceptible to erosion. The maintenance of soil residue cover is key to improved soil productivity in this region and many of the region's cropping systems utilize reduced and no-tillage practices.

The literature is extensive regarding the effect of tillage and residue management on soil organic matter and resulting changes in soil physical and chemical properties. Tillage can mask crop rotation responses and rotation can alleviate potential adverse effects of reduced tillage on certain soils. However, the effects of cropping sequence on properties of soils under no tillage management have not been extensively studied. The amount of residues deposited, their composition, and their resistance to mineralization varies between plant species and often interacts with crop sequence and tillage practice. Plant materials with a high C: N ratio (corn, wheat) and great residue yield may be preferable to fasted the accumulation of organic matter in these soils because the hot humid climate provides an environment where residues decompose rapidly. Under these conditions, plant materials with high C: N ratios and/or lignin contents, which in turn produce a longer lasting mulch, may be preferable. Corn and wheat residues are examples of such plant materials.

The objective of this study was to identify the effects of several corn-based crops sequences on the properties of a Paleudalf under continuos no tillage management.

MATERIALS AND METHODS

The experimental site was located near Lexington (Kentucky, USA) on a Paluedalf (clay = 26 %, silt = 67 %). In 1990, the following 4 crop sequences were established in a randomized block design and with 4 replicates:

A= Continuous corn(C-C-C)
B= Corn - Wheat/Soybean - Corn(C-W/S-C)
C= Corn - Soybean - Corn(C-S-C)
D= Forage - Forage - Corn(F-F-C)

The no-tillage management of the plots used only chemical weed control just prior to and shortly after crop establishment (pre-emergence//post-emergence). Wheat crops were sown late October, corn and soybean crops in May and soybean as a double crop immediately after the wheat harvest in July. The clover in the forage treatment was sown in March and the grass in the prior October. Nitrogen fertilizers were applied to corn and wheat crops. Potassium fertilizers were applied in all the treatment with a higher rate used in the forage plots. Liming was done whenever called for by soil analysis.

During establishment of the summer crops in 1998 composite soil samples were taken at 0 to 3 and 3 to 6 in depths. The following analyses were performed on the air-dried soil samples: organic matter (dry combustion), total nitrogen (Kjeldahl), phosphorus, potassium, calcium and magnesium (Mehlich-3 extraction) and pH in water (1:10 ratio). The total amount of organic matter in each layer was calculated from the product of the sampled depth and the bulk density (Uhland sampler). All the soil properties were subjected to correlation analysis and ANOVA in two factors (crop sequence and depth) and means were separated by the LSD (T) significance test.

RESULTS AND DISCUSSION

The crop sequence and sampling depth did not interact significantly where pH, P, Ca, Mg and bulk density (BD) values are concerned. The first of these four properties were higher in the 0 to 3 in layer than in the deeper layer. No differences between depths were observed in the BD values (table 1).

The crop sequence that included 2 years of forage before planting the corn crop (Treatment D) induced a greater accumulation of soil organic matter (SOM) in the 2 sampled layers (table 2). When the row crop sequences were considered (Treatments A, B and C) differences in SOM were found only in the top layer, with the highest values observed in the continuos corn treatment (table 2). From the strong relationship between SOM and total N values ($r = 0.989$, $p<0.01$) it was deduced that although the different crop residues have different initial quality, the C:N in the soil remains practically constant. The differences in the extractable K levels between the crop sequences observed in the 0 to 3 in layer can be explained on the basis of the high fertilization rate in treatment D. No significant effects of SOM on the BD (compaction) status of the soil were observed.

The dry matter production of the forage plus the corn residue after harvest in treatment D was significantly higher than the crop residue left in the other treatments. In Fig. 1 it can be observed that the stored SOM in the cup 0 to 6 in layer of this soil was higher only under the F-F-C rotation. The insignificant differences between the row crop sequences reflect the minor variations in the accumulation pattern of the residues in these sequences.

Table 1: Effects of four crop sequences on soil ph, extractable P, Ca, and Mg and bulk density (BD) levels of a paleudalf under continuos no tillage management. Averages by depth or by crop sequence. Columns means followed by the same letter are not significantly different (tukey, p<0.05).

Crop Sequence	pH	P	Ca	Mg	BD
		----------------------lb acre^{-1}----------------------			g cm^{-3}
(A) C-C-C	6.15 b	93.0 a	3450 a	219.9 b	1.30 ab
(B) C-W/S-C	6.07 b	104.1 a	3337 a	217.6 b	1.28 b
(C) C-S-C	6.37 a	101.4 a	3662 a	243.5 a	1.34 a
(D) F-F-C	6.19 b	107.4 a	3517 a	213.5 b	1.33 a
Depth	pH	P	Ca	Mg	BD
		----------------------lb acre^{-1}----------------------			g cm^{-3}
0-3 in	6.27 a	112.2 a	3668 a	242.9 a	1.32 a
3-6 in	6.12 b	90.7 b	3315 b	204.4 b	1.31 a

Table 2: Effects of four crop sequences on soil organic matter (som), total Nitrogen (Nt) and extractable K in two sampling depths of a Paleudalf under continuos no-tillage management. Columns means followed by the same letter are not significant different (tukey, p<0.05).

	Depth					
	0-3 in			3-6 in		
	SOM	Nt	K	SOM	Nt	K
Corn Sequence	------------ % -----------		lb acre^{-1}	------------% ----------		lb acre^{-1}
(A) C-C-C	3.39 b	0.202 ab	355 b	2.22 b	0.149 b	188 a
(B) C-W/S-C	3.11 c	0.190 bc	345 b	2.35 ab	0.152 ab	176 a
(C) C-S-C	2.96 c	0.181 c	346 b	2.23 b	0.146 b	180 a
(D) F-F-C	3.62 a	0.216 a	566 a	2.52 a	0.162 a	197 a

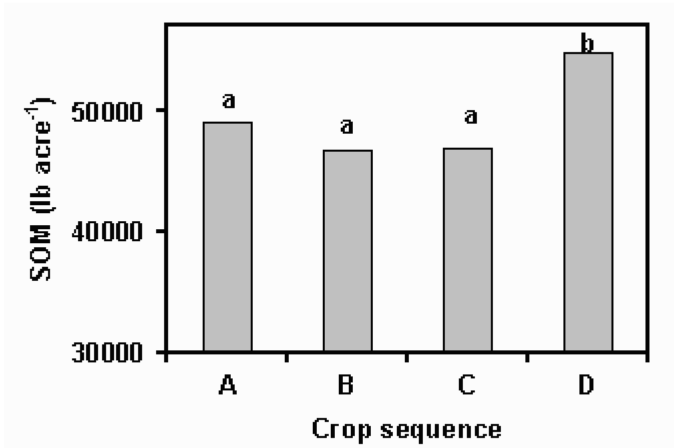


Fig. 1. Soil organic matter level in the 0 to 6 in layer of a Paleudalf under 4 crop sequences. Bars topped by the same letter are not significant different (Tukey, p<0.05).

CALIBRATION OF THE ROOT ZONE WATER QUALITY MODEL FOR SIMULATING NITRATE AND PESTICIDE LOSS IN COTTON PRODUCTION SYSTEMS IN THE SOUTHERN PIEDMONT OF GEORGIA

D.A. Abrahamson[1], D.E. Radcliffe[2], J.L. Steiner[3], J.D. Hanson[4], K.W. Rojas[5], and Gerrit Hoogenboom[6]

AUTHORS: [1]Hydrologist and [3]Research Soil Scientist, USDA-ARS-JPCNRCC, 1420 Experiment Station Road, Watkinsville, GA 30677; [2] Professor, University of Georgia, Athens, GA; [4]Research Plant Physiologist, USDA-ARS, Mandon, ND; [5]Computer Programmer/Hydrologist, USDA-ARS Great Plains System Research Unit, Ft. Collins, CO. [6]Crop Modeler, Biological and Agricultural Engineering Department, University of Georgia, Griffin, GA. Corresponding Author: Deborah Abrahamson, Email: dstark@arches.uga.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Southern Annual Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

RESEARCH QUESTION

In Georgia, as cotton production increases and broiler litter continues to become a viable alternative to commercial fertilizer due to its availability and organic nature, we must learn how the nutrients in broiler litter might affect ground- and surface-water quality in cotton production areas. Similarly, there is a need to understand how pesticides used in production agriculture affect water quality. A study was established at the USDA-ARS, Watkinsville, Georgia in 1996 to look at the effects of no-till versus conventional-till management practices and broiler litter versus conventionally-fertilized treatments on nitrate and pesticide losses from cotton in the Southern Piedmont. In order to extrapolate the findings of the study, we chose to calibrate and test the Root Zone Water Quality Model (RZWQM98) to simulate these losses.

LITERATURE SUMMARY

Several models are available to predict nutrient and pesticide losses in agricultural production systems. Many of these models do not incorporate all aspects of the system being modeled. Environmental parameters such as management history of the site, micro-organism and nutrient pool establishment, or well-developed equations for drainage or evapotranspiration are neglected. Some of these models have been tested at the proposed study site in Watkinsville and were not able to accurately predict drainage or nutrient losses from the system.

The Root Zone Water Quality model has been developed over the past ten years by USDA-ARS scientists at the Great Plains System Research unit in Ft. Collins, Colorado. RZWQM98 is a process-based model that simulates major physical, chemical and biological processes in crop production systems under a range of common management practices. It includes simulation of a tile drainage system and runoff as well as predictions of the potential for ground- and surface-water contamination. RZWQM98 also includes options for various degrees of crop parameterization for any crop, and well-developed equations for water movement through the plant-soil-water continuum, an essential part of a model's ability to accurately predict nutrient and pesticide losses.

MATERIALS AND METHODS

In order to accurately simulate a field production system for nitrate and pesticide losses, a model must first be able to accurately simulate soil water dynamics, nitrogen transformation, and plant production for a given soil and climatic environment. We have 15 years of data on cropping practices and management history as well as hydrology, climate, and soil physical characteristics collected from the study area prior to the cotton study begun in 1995. This will allow us to set up and calibrate the model for soil water dynamics, decomposition cycles and plant production capabilities. The plant growth option of the RZWQM98 will be calibrated using one year of cotton production data from a field adjacent to the study site under similar soil and management practices in 1997. This will insure that the parameters used in the production component can accurately simulate cotton growth. This will be the first time the model is calibrated and used to simulate cotton. The water balance and nutrient-cycling portions of the model will be calibrated based on data collected from the cotton study site from 1991 to 1994 including drainage, runoff, and soil moisture as well as measured nitrates in drainage and runoff, amount of residue in no-till treatments, etc. and from values in the literature regarding microbial populations and organic carbon pools in the soil.

RZWQM98 requires fairly extensive initial parameterization. However, with its comprehensive user interface and on-line scientific as well as software-specific help utility, the model can be set up with little or no more effort than models that require simpler and less detailed input. After calibration, the model should represent a starting point very similar to field conditions for the cotton study we will test for nutrient and pesticide losses using runoff, drainage from drain tiles 90 cm below the surface, and soil samples from each treatment plot analyzed for nitrate and pesticide content from 1996 to 1999.

APPLIED QUESTIONS

1. Will the RZWQM98 accurately predict leaching of nitrates and potential contamination of surface and ground-water water resources from cotton produced under no-till versus conventional-till and broiler litter versus conventionally fertilized treatments?

A calibrated model that can accurately predict losses of nutrients, especially nitrate, to groundwater as well as to rivers, lakes and streams from fields in production agriculture would give us a tool to test various management scenarios for cotton and other crops while working to maintain the quality of our soil and water resources. The amount of broiler litter that needs to be utilized is increasing every year in Georgia. Nitrate in groundwater must be maintained below maximum levels established by the US Environmental Protection Agency as we continue to use litter as a fertilizer on crops and pastures.

2. Will the RZWQM98 accurately predict contamination of surface and ground-water resources from pesticides in cotton produced under these same treatments?

Potential contamination from pesticides commonly used in cropping systems is as important as potential contamination from nutrients. Although pesticides are currently being developed that are more organic in nature and less harmful to the environment, we still rely on chemical pesticides for now to maintain healthy crops and high yields. A model that can accurately predict pesticide movement and loss in a cropping system can be used as a tool to predict types and amounts of potential contaminants to our soil and water. It would also help us to understand how pesticides currently affect these resources and find ways to avoid problems in the future.

COTTON YIELD AND FIBER PROPERTIES AS INFLUENCED BY RESIDUE COVER, TILLAGE, AND ALDICARB

Philip J. Bauer[1], John A. DuRant[2], and James R. Frederick[2]

AUTHORS:[1]USDA-ARS, Coastal Plains Soil, Water, and Plant Research Center, 2611 West Lucas Street, Florence, SC 29501-1242; [2]Clemson University, Florence, SC. Corresponding Author: Philip Bauer, Email: bauer@florence.ars.usda.gov
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Coastal Plain fields generally contain several soil map units, and crop variability within a field is due in large part to differences in soil map units. Identifying crop responses to management inputs on the different soil types will be useful for site-specific farming applications. The objective of this experiment was to determine the effect of soil management techniques and in-furrow application of an insecticide/nematicide on cotton yield and fiber properties.

Data in this report are from the second year (1988) of a six-year study. Treatments were residue cover (corn stubble, rye winter cover crop, or cotton stubble), tillage (conservation or conventional), and aldicarb application (1.07 lbs a.i./acre or none). 'DPL Acala 90' was planted into large plots (ranging in length from approximately 400 to 800 feet, plots were six, 38-in-wide rows) that spanned across several soil types. Two harvesting methods were used to determine variability. First, the large plots were subdivided into 44-ft-long sections, two of the rows in each section were harvested with a spindle picker, and average yield and fiber property values were calculated for the entire plot. Second, a 10-foot sample was hand-harvested from each of three soil map units (Bonneau sand, Eunola loamy sand, and Norfolk loamy sand) within each plot.

For both methods of harvesting, residue cover did not influence cotton yield or fiber properties. A significant tillage X aldicarb interaction occurred for lint yield in the machine-harvested data. Without aldicarb, lint yield for conservation tillage was about 150 lbs ac^{-1} higher than for conventional. With aldicarb, yield for conservation tillage was about 200 lbs ac^{-1} higher than for conventional tillage. The cotton grown with conventional tillage had higher micronaire than cotton grown with conservation tillage. Otherwise, neither tillage nor aldicarb had an impact on fiber properties.

Although lint yield was greater for conservation tillage than for conventional tillage when harvested with a spindle picker and averaged over entire plots, the hand-harvested data revealed that the yield increase with conservation tillage was soil map unit specific. For the hand-harvested data, yield for conservation tillage was only 35 lbs lint ac^{-1} greater than for conventional on the Bonneau soil map unit, while the average yield increase for conservation tillage was 170 lbs lint ac^{-1} on the Norfolk and Eunola soil map units. Similarly, the response of cotton micronaire and fiber strength to tillage was dependent on soil map unit with the responses on the Bonneau differing from the responses on the Norfolk and Eunola. Cotton grown with conservation tillage had fibers that were 0.02 inches longer than cotton grown with conventional tillage, regardless of the soil type. Aldicarb treatment did not significantly affect yield or fiber properties of the hand-picked cotton as it did for the spindle-picked, possibly because of fewer data points in the analysis.

In this second year of the study, conservation tillage did not appear to affect yield variability, but fiber properties were more uniform in conservation tillage than in conventional.

SOIL STRENGTH FOR VARYING SOIL TYPE AND DEEP TILLAGE IN A COASTAL PLAIN FIELD WITH HARDPANS

W.J. Busscher[1], P.J. Bauer[2], J.R. Frederick[3]

AUTHORS: [1]Soil Scientist and [2]Agronomist, USDA-ARS, Coastal Plain Research Center, 2611 W Lucas St. Florence, SC 29501-1242; [3]Associate Professor of Agronomy, Clemson University, 2200 Pocket Road., Pee Dee Research Center, Florence, SC 29506-9706. Corresponding author W. J. Busscher, Email: busscher@florence.ars.usda.gov.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95, Athens, GA.

SUMMARY

When a double crop management system with drilled soybean and wheat led to high yields in deep-tilled small plots, we decided to evaluate the management system in large plots in a field with variable soil types. Double-cropped soybean and wheat were drilled in 7.5-inch row widths using all combinations of surface tillage (disked or none) and deep tillage (paratilled or none) with one extra set of paratilled treatments that were rotated with corn using in-row subsoiling. Cone indices were measured at two places in each plot to assess soil strength differences within and among treatments. Cone indices were higher for soil types with shallower B horizons. Subsoiled treatments had higher cone indices than paratilled treatments, partially as a result of drier soil. When compared to non-disked treatments, disked treatments had equal or higher mean profile cone indices even if treatments were deep tilled after disking. In fact, at the position of maximum disruption by deep tillage, treatments had higher cone indices if they were disked than if they were not disked. A reduction in the loosening effect of the final deep tillage can be affected by earlier surface tillage.

INTRODUCTION

High soil strength, enough to prevent root growth and reduce yield, is found in many southeastern Coastal Plain soils. Though the strength builds up naturally, it can be accelerated by traffic. High strength in these soils is often associated with an E horizon, located just below the Ap.

Currently accepted management of the high-strength layer reduces its strength by deep tillage. Since the hard layer reconsolidates within a year, soils are generally deep tilled annually (Threadgill, 1982, Busscher *et al.*,1986; Porter and Khalilian, 1995), even for double crops. Recently, when the hard layer was disrupted by deep tilling before both wheat and soybean, yields increased significantly (Frederick *et al*., 1998).

Currently, some deep-tillage management schemes include surface tillage (disking) and some do not. Regardless of whether the soil is disked or not, deep tillage that follows disking loosens the profile to depths of 14 to 16 inches. Implicit in this management practice is that the deep tillage will reduce soil strength to a point that is conducive to root growth regardless whether the surface is tilled or not.

Our purpose was to use an intensive management system that deep tills before every crop, compare soil strengths measured at two places within and among treatments in large plots, and determine whether disking would affect subsequent deep tillage.

METHODS

In fall of 1996, we established wheat-soybean, double-cropped plots using cultivar Northrup King Coker 9134[1], soft red winter wheat, and Hagood soybean. Plots were 30-ft wide and 500-ft long.

Plots were located in a field that had Bonneau (Arenic Paleudult), Goldsboro (Aquic Paleudult), Noboco (Typic Paleudult), and Norfolk (Typic Kandiudult) as its major soil types. Soils had E horizons below the plow layer that hardened and restricted root growth.

Plots had two surface tillage and two deep tillage treatments in three randomized complete block replicates. The two surface tillage treatments were either not disked or disked twice before planting. Each surface tillage treatment also had a deep tillage treatment of either no paratilling or paratilling before both soybean and wheat planting. Deep tillage treatments were duplicated so that one set could be rotated into corn in the second year of the experiment.

For wheat and soybean, surface tillage, deep tillage, and planting were done in separate operations. Before planting wheat or soybean, plots were deep tilled with a paratill. Corn was planted and in-row subsoiled with a 45° forward-angled, 1-inch-wide, straight-shanked subsoiler in one operation. All tillage and harvesting equipment followed the same wheel tracks as closely as possible.

[1] Mention of trademark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by the U.S. Dept. of Agric. or Clemson University and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

Both wheat and soybean were drilled in 7.5-inch row widths with a 10-ft-wide no-till drill. Wheat was drilled in mid November at a rate of 20 seeds/ft and harvested in late May or early June. Soybean were drilled in early June at a rate of 4 seeds/ft and harvested in early November. In the second year of the experiment, corn was rotated into the extra set of deep-tilled treatments. After a fallow winter for these treatments, corn was planted in mid-March at a rate of 24,000 seeds/a.

All plots were fertilized following Clemson soil test recommendations (Clemson University, 1982). Weeds were controlled with Roundup (glyphosate) before wheat planting or Bronco (alachlor plus glyphosate) before soybean planting. Disked treatments were sprayed with Lasso before soybean emergence. After soybean planting, broadleaf weeds and nutsedge were controlled with Classic, and annual grasses were controlled with Poast Plus.

Within two weeks after planting either wheat or soybean and several weeks after planting corn, data were taken with a cone penetrometer (Carter, 1967). Cone indices were measured to a depth of 22 inches at 4-inch depth intervals at 9 positions across the rows beginning between the wheel tracks and ending in a wheel track, centering on the zone of maximum disruption of a deep tillage shank whenever appropriate. Cone indices were taken at two locations 50 to 100 ft from each end of each plot. Data were digitized into the computer and log transformed for analysis (Cassel and Nelson, 1979). Soil water contents were taken along with cone indices. They were measured at 4-inch depth intervals from the surface to 24-inches deep.

Data were analyzed using ANOVA and the least square mean separation procedure (SAS Institute, 1990). Cone index and water content data were analyzed using a split-split plot randomized complete block design where main effects were surface and deep tillage. The first split was on position across the row; the second, on depth. Data were tested for significance at the 5% level unless otherwise specified.

RESULTS

Water contents were generally not different and did not affect soil cone indices except as mentioned below. Cone index analyses were separated into two parts: before rotation with corn and after rotation. Before rotation, data from treatments that were to be rotated were averaged with the deep-tilled treatments.

For the readings taken before rotation, paratilled treatments had lower cone indices than the treatments with no deep tillage. Cone indices for fall 1996 and spring 1997 were 11.6 (1.099) and 10.4 atm (1.059) for the paratilled treatments while they were 17.6 (1.269) and 20.7 atm (1.336) for non-deep tilled treatments (LSD's at 5% were 0.044 and 0.034). (Note: Numbers in parentheses are logs of the cone indices plus 1 atm. The addition of 1 atm prevents us from taking log of zero. Logarithms are shown along with cone indices because analyses are based on log transforms.) In the depth by deep tillage interaction, cone indices for deep-tilled treatments were lower than non-deep-tilled treatments to a depth of 14 inches; tillage was generally to 16 inches. Lower cone indices would encourage root growth and improve yield (Sojka *et al.*, 1991).

The depth by surface tillage interaction was significant because of a disk pan. In the 8- to 10-inch depths of the disked treatments, cone indices were at least 2.2 atm higher than in the non-disked treatments (Fig. 1). Despite disruption by the disk, cone indices for the disked treatments were not always lower than the non-disked treatments in the zone above the pan. Disking always increased cone indices in the pan but did not always reduce cone indices above it.

The depth by location of measurement interaction was significant because cone indices for the Goldsboro and Noboco soils at one measurement site, one end of the plots, were lower near the surface, above 8 inches, and higher in the lower part of the profile, below 8 inches, than the cone indices for the Bonneau and Norfolk soils at the other measurement site, the other end of the plots. This difference was at least partly a result of soil type because we noted at the time of measurement that the B horizon for the Goldsboro and Noboco soils appeared to be harder and closer to the surface than for the Bonneau and Norfolk. The difference was not a result of soil softening by increased water content because harder soils, above 8 inches in the Bonneau and Norfolk and below 8 inches in Goldsboro and Noboco, were also wetter.

The interaction of position and deep tillage was significant because it showed where the deep tillage had lowered cone indices (Fig. 1). Though the shanks had been set at 26-inch intervals, a recommended interval for complete loosening, cone indices revealed where the shanks had disrupted the soil and where high strength remained between the shanks: remnants of the pan. The profile was not uniformly disrupted across the profile.

Cone indices for the three way interaction of position by surface tillage by deep tillage was significant because disking increased cone indices, even for the treatment that was deep tilled after disking. In both fall and spring, cone indices for non-disked, paratilled treatment were lower than for the disked, paratilled treatment at the position where the shank disrupted the soil at its deepest point (Table 1), a sort of hysteresis effect for tillage.

In fall 1997, the rotated treatments were fallow. Paratilled treatments again had lower cone indices than non-paratilled treatments. Cone indices were 20.5 atm (1.332) for treatments with no deep tillage, 15.0 atm (1.205) for treatments that were fallow (but had been paratilled the previous spring), and 11.3 atm (1.091) for treatments that had been paratilled for the winter wheat (LSD at 5% was 0.048). No deep-tillage in treatments that had been deep tilled in the previous spring increased cone indices, but not as much as no deep tillage at all.

Corn was planted into the rotated treatments in March with in-row subsoiling. By the time of cone index measurement, June, soil in the rotated treatments had partially dried as a result of evapotranspiration. The mean water contents were 10.5% for the paratilled treatment, 10.1% for the non-deep-tilled treatment planted to soybean, and 8.4% for the rotated treatment (LSD at 5% was 1.1%).

Even though the rotated treatment had been subsoiled, its dryness caused it to have a high mean cone index (22.7 atm - 1.374). It was as high as the treatment that had not been deep tilled (22.0 atm - 1.361) and both were higher than deep-tilled treatment (16.7 atm - 1.249, LSD at 5% was 0.060).

The depth by surface tillage interaction was significant because of both the loosened zone by disking and the disk pan. In fall 1997 and spring 1998, this was seen by the lower cone indices at the 2-inch depth and higher cone indices at the 6- to 8-inch depths. For the two dates of measurement, cone indices within the pan of the disked treatments were 3.2 atm to 4.1 atm higher than non-disked treatments, with maximum cone indices within the pan at 20 and 30 atm which were at or above root limiting values (Blanchar *et al*., 1978; Taylor and Garner, 1963).

As with the readings before rotation, depth by location of measurement cone indices were significantly different. In fall 1997, cone indices were lower for the Goldsboro and Noboco soils above 6 inches and higher below 6 inches than for the Bonneau and Norfolk soils and, in spring 1998, lower above 6 inches and higher below 14 inches. As before, higher cone indices also had the same or higher soil water contents; so water content was not a factor in reducing cone index. Goldsboro and Noboco soils had higher cone indices in heavier textured B horizons closer to the surface.

Cone index interaction of position with deep tillage were significant because of lower readings where the soil had been deep tilled. Fewer positions across the soil had low cone indices for the subsoiled (rotated) treatment than for the paratilled treatment (Fig. 2). In fall, this was caused by a lack of deep tillage and represented only remnants of deep tillage done the previous spring. In spring, this was caused by drier, harder soil for the subsoiled treatment, soil settling or reconsolidation during the almost three months between tillage and cone index reading, and a shallower, narrower zone of disruption with the subsoil shank than with the paratill (Busscher *et al*., 1988). Nevertheless, we expected that the corn root growth would not have suffered from lack of tillage because roots would have been able to penetrate the hard layers in March when the soil would have been softer.

As seen in the data before rotation, cone indices for the three way interaction of position by surface tillage by deep tillage was significant because disking increased cone indices, even for the treatment that was deep tilled after disking. Cone indices for treatments that were either subsoiled or paratilled were higher for the disked than for the non-disked treatment at the position of maximum disruption by the shank (Table 1).

Both before and after rotation, disked treatments had equal or higher mean profile cone indices than non-disked treatments. Before rotation, non-paratilled treatments had higher mean profile cone indices than paratilled treatments. After rotation, non-deep tillage treatments had higher mean profile cone indices than subsoiled treatments (in the zone of disruption) which had higher cone indices than paratilled treatments. Higher cone indices in the subsoiled than in the paratilled treatment was a result of dryer soil. The subsoiled treatment had been deep tilled about three months before cone index measurements were taken and soil was drier in that treatment because it had dried by evapotranspiration.

Before and after rotation, Goldsboro and Noboco soils had lower cone indices shallow in the horizon and higher cone indices deeper in the horizon than Bonneau and Norfolk soils. This was partly a result of the heavier textured B horizons closer to the surface of the Goldsboro and Noboco.

Disking increased cone indices, even for the treatment that was deep tilled after disking, as measured at the position of maximum disruption by the paratill or subsoil shank, indicating to a possible hysteretic effect for tillage.

REFERENCES

Blanchar, R.W., Edmonds, C.R., and Bradford, J.M. 1978. Root growth in cores formed from fragipan and B2 horizons of Hobson soil. Soil Sci. Soc. Am. J 42:437-440.

Busscher, W.J., Karlen, D.L., Sojka, R.E., and Burnham, K.P. 1988. Soil and plant response to three subsoiling implements. Soil Sci. Soc. Am. J. 52:804-808.

Busscher, W.J., R.E. Sojka, and C.W. Doty. 1986. Residual effects of tillage on Coastal Plain soil strength. Soil Sci. 141:144-148.

Carter, L.M. 1967. Portable penetrometer measures soil strength profiles. Agric. Eng. 48:348-349.

Cassel, D.K., and Nelson, L.A. 1979. Variability of mechanical impedence in a tilled one hectare field of Norfolk sandy loam. Soil Sci. Soc. Am. J. 43:450-455.

Clemson University. 1982. Lime and fertilizer recommendations based upon soil test results.

Cooperative Extension Service Cir. #476, Clemson, SC.
Frederick, J.R., Bauer, P.J., Busscher, W.J., and McCutcheon, G.S. 1998. Tillage management for doublecropped soybean grown using narrow and wide row-width culture. Crop Sci. 38(3):755-762.
Porter, P.M., and Khalilian, A. 1995. Wheat response to row spacing in relay intercropping systems. Agron. J. 87:999-1003.
SAS Institute Inc. 1990. SAS/STAT User's Guide, Vol. 2, SAS. Inst. Inc., Carey, NC.
Sojka, R.E., Karlen, D.L., and Busscher, W.J. 1991. A conservation tillage research update from the Coastal Plain Soil and Water Conservation Research Center of South Carolina. Soil Till. Res. 21:361-376.
Taylor, H.M. and Gardner, H.R., 1963. Penetration of cotton seedling taproots as influenced by bulk density, moisture content, and strength of the soil. Soil Sci. 96:153-156.
Threadgill, E.D. 1982. Residual tillage effects as determined by cone index. Trans. ASAE 25(4):859-863.

Table 1. Cone indices for the surface tillage by deep tillage by position interaction (at the point of maximum disruption of the deep tillage) showing hardness of disked treatments even after deep tillage.

Date of	Surface	Deep Tillage		
Measurement	Tillage	None	Paratill	Subsoil
		- - - - - Cone Indices - Atm (log)* - - - - -		
Fall 1996	Disked	17.9 (1.276)	11.1 (1.084)	- -
	None	18.2 (1.283)	9.4 (1.017)	- -
Spring 1997	Disked	21.0 (1.342)	7.4 (0.923)	- -
	None	20.2 (1.325)	5.2 (0.793)	- -
Fall 1997	Disked	19.8 (1.319)	7.2 (0.915)	10.3 (1.054)
	None	20.8 (1.339)	5.3 (0.797)	9.9 (1.037)
Spring 1998	Disked	22.0 (1.361)	13.8 (1.172)	19.9 (1.320)
	None	19.1 (1.302)	12.8 (1.141)	15.6 (1.221)

* The numbers in parentheses are logs of the cone indices in atmospheres plus 1 atm. The addition of 1 atm prevents us from taking log of zero. Logarithms are shown along with cone indices because analyses are based on log transforms. The LSD's for the logs are 0.058 at 10% for Fall 1996, 0.067 at 5% for Spring 1997, 0.072 at 5% for Fall 1997, and 0.062 at 5% for Spring 1998.

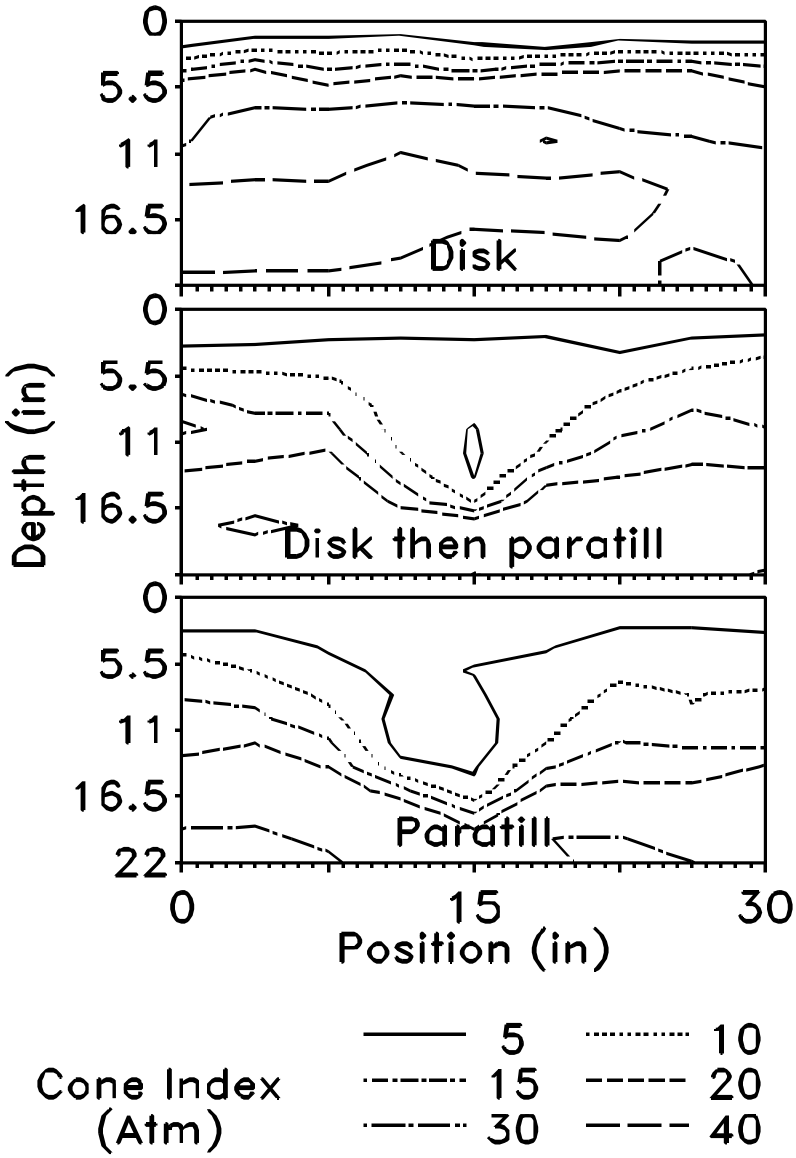


Figure 1. Cone index contours in June 1997. Tillage treatments are disking only, disking followed by paratilling, or paratilling only.

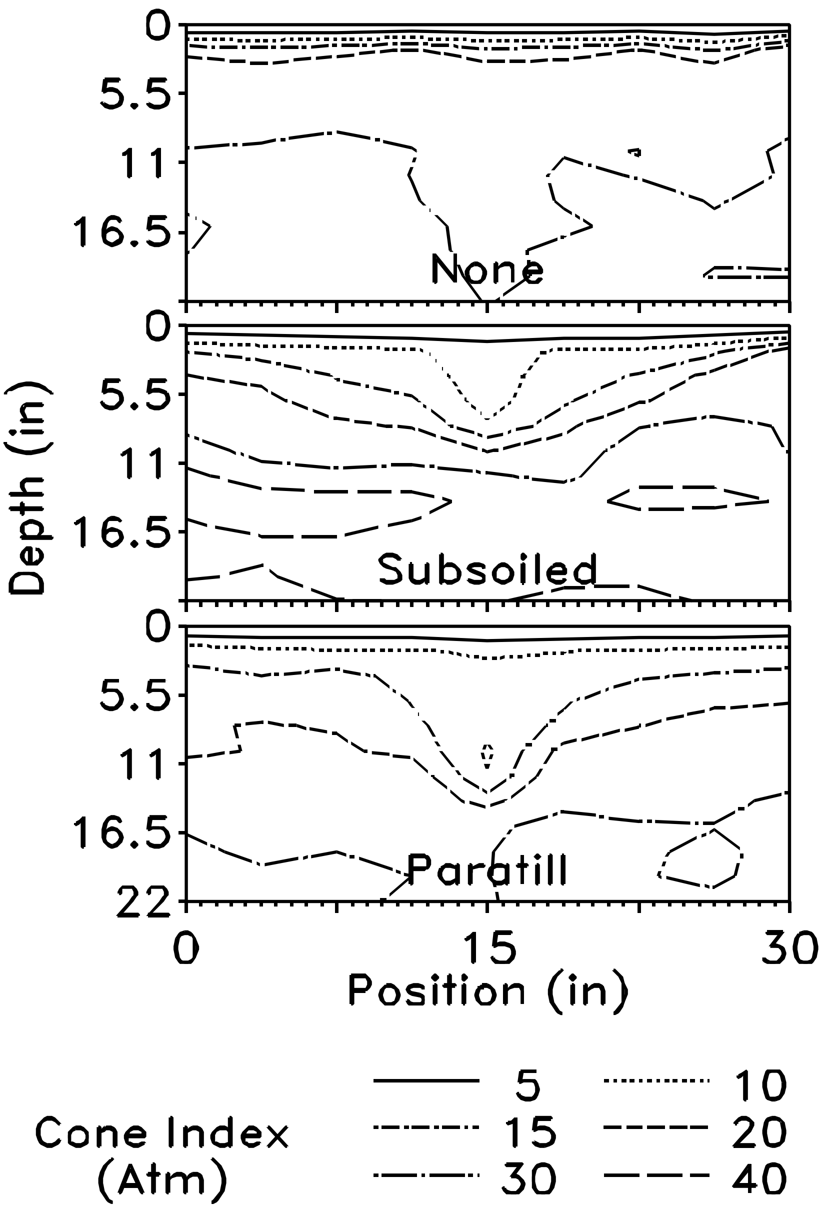


Figure 2. Cone index contours in June 1998 (non-disked treatments only). Deep tillage treatments are none, subsoiled, or paratilled.

NITROGEN AND TILLAGE COMPARISONS OF CONVENTIONAL AND ULTRA NARROW ROW COTTON

D. L. Wright[1], P. J. Wiatrak[1], J. A. Pudelko[2], B. Kidd[1], and W. Koziara[2]

AUTHORS: [1]National Florida Research Environmental Center, Quincy, FL 32351; [2]Agriculture University Institute of Soil Culture and Plant Production, Mazowieka 45/46, 40-623 Poznan, Poland.

REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTERPRETIVE SUMMARY

Cotton production increased rapidly in Florida, from about 12,000 acres in 1985 to 98,000 acres in 1996 with the production of 130,000 Bales in 1996. According to Touchton and Reeves (1988), conservation tillage systems have a beneficial effect on cotton production in the sandy coastal plain soils of the southeastern states, but the natural formation of tillage pans has been recognized as a limiting in these soils. Previous research results suggest that detrimental effects of traffic on N uptake efficiency may be reduced with conservation tillage systems and that higher fertilizer N application rates may not be needed for conservation tillage practices such as strip-till in Coastal Plain soils. The objectives of this research were to compare minimum and conventional tillage for cotton planted in 36" and 7" row spacings with different N rates on cotton.

This research was conducted in 1997 and 1998 on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) located at the North Florida Res. and Educ. Center (NFREC), Quincy, FL. We compared 36" row-spaced cotton planted with a strip-till planter to ultra-narrow row cotton (UNR) with 7" row width planted with a Great Plains no-till drill (both planted in minimum and conventional tillage). Three N rates (0, 60, 120 lb N acre^{-1}) were applied in 1997 and four (0, 60, 120, and 180 lb a.i. N acre^{-1}) were applied in 1998.

RESULTS

- Number of bolls per plant generally increased with higher N rates and were higher on plants from conventional rows than UNR
- Higher yields of cotton were obtained at higher N rates in 1997 and were opposite due to drought and hard lock bolls in 1998.
- Significantly higher yields were obtained on UNR as compared to conventional row widths in both years.

See this full paper and its tables and figures in the Reviewed Papers Section of this Proceedings.

IMPACT OF COMPOST AND TILLAGE ON SWEET CORN YIELD, SOIL PROPERTIES, AND NEMATODES

J. D. Greenwood[1], R.N. Gallaher[2], and R. McSorley[3]

AUTHORS: [1] Graduate Research Assistant and [2] Professor, Department of Agronomy, and [3]Professor, Department of Entomology and Nematology, Institute of Food & Agriculture Science, University of Florida, Gainesville, FL 32611. Corresponding Author: J.D. Greenwood, Agronomy Department, PO Box 110730, University of Florida, Gainesville, FL 32611-0730; E-mail: bahia@ufl.edu ;
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTERPRETIVE SUMMARY

Recycling of urban plant debris as yard waste compost (YWC) requires extensive research in Florida and the USA. This research investigated the use of YWC as a fertilizer amendment and its effect on soil quality and sweet corn yield. Data show that the effect of YWC is for sweet corn yields of fancy grade ears to increase by as much as 70%. Extension fertilizer recommendations can possibly be cut by one-half under these old YWC additions, whereas the control required the full recommendation. Soil quality is highly improved as evidenced by a large reduction in bulk density and by increase in soil water holding capacity of 70 to 150%, depending upon the old and new YWC treatment combination. The more favorable soil quality from addition of YWC resulted in increased corn yield. Greater numbers of root-knot nematode were associated with a more favorable soil environment. The healthier corn likely provided a good host environment for increased root-knot nematode numbers.

See this full paper and its tables and figures in the Reviewed Papers Section of this Proceedings.

GIBBERELLIC ACID USE IN STALE SEED BED RICE PRODUCTION

P. K. Bollich[1] and R. T. Dunand[1]

AUTHORS: [1]Professors, Louisiana Agricultural Experiment Station, Rice Research Station, P.O. Box 1429, Crowley, LA 70527-1429; Corresponding author: P.K. Bollich, Email address: pbollich@agctr.lsu.edu;
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTERPRETIVE SUMMARY

Uniform emergence and adequate stand establishment are necessary for optimum yields in drill-seeded rice cultural systems. In recent years, most rice varieties that have been developed for commercial production are semidwarf plant types. These short stature rice varieties are often slow to emerge through the soil because of the reduced length of the coleoptile and mesocotyl. Gibberellic acid (GA) is a plant growth regulator that is very effective in improving rice emergence and stand establishment when used as a seed treatment. The first commercial uses of GA were oriented toward conventional tillage rice systems, which remains the predominant tillage system in U.S. rice production. There has been considerable interest in conservation tillage rice systems in recent years due to environmental concerns related to soil and nutrient loss associated with conventional tillage. Conservation tillage systems also show potential for decreasing production costs. In Louisiana, approximately 17% of the total rice acreage is devoted to some form of conservation tillage practice. The objective of this study was to determine if a GA seed treatment could provide the benefits realized in conventional tillage systems to a stale seedbed system.

An experiment was conducted in 1997-1998 to evaluate the response of GA-treated seed in a stale seedbed rice system and to determine the effect of variable seeding rate on rice production. In 1997, rice emergence and stand density were both increased with GA seed treatment, and this response was typical of the response found in conventional tillage systems. There are usually no direct benefits from GA associated with grain production unless stand densities are below minimum levels (<10 plants/ft^2), and in this experiment, grain yields were significantly lower with a seeding rate of 50 lb/A and no seed treatment. Final stand density at this seeding rate was less than 20% of the minimum required for optimum yield. When GA seed treatment was used, grain yield increased to levels measured at higher seeding rates. In 1998, stand densities averaged over tillage method and seeding rates were again increased with GA seed treatment, but grain yield was not affected. Seeding rates independently affected grain yield, and yield was significantly lower when stand densities were less than the minimum required.

This experiment demonstrated that GA seed treatment could improve emergence and stand establishment in stale seedbed rice systems. It is also important to recognize the contribution stand density makes toward grain production. Reduced seeding rates are of interest as a means of decreasing production costs, and while GA seed treatment can improve stand establishment at lower seeding rates, it is essential to maintain minimum plant populations (10 plants/ft^2) to insure grain yields are not reduced.

See this full paper and its tables and figures in the Reviewed Papers Section of this proceedings.

TOMATO YIELD AND SOIL QUALITY AS INFLUENCED BY TILLAGE, COVER CROPPING, AND NITROGEN FERTILIZATION

Upendra M. Sainju[1], Bharat P. Singh[1], and Sidat Yaffa[1]

AUTHORS: [1]Agricultural Research Station, Fort Valley State University, Fort Valley, GA 31030; Corresponding author (sainjuu@mail.fvsu.edu)
REFERENCE: J. E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*. Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTERPRETIVE SUMMARY

Vegetable production systems, such as tomato, require intensive management and high input of nitrogen compared with cereal production systems. Nitrogen uptake in vegetable crops is also lower than in cereal crops. As a result, soil and water quality can be degraded due to increased soil organic matter mineralization and erosion and nitrate pollution in the groundwater more under vegetables than under cereal crops. Therefore, practices that conserve soil and nutrients are needed for improved soil and water quality and sustained vegetable production.

We examined the influence of tillage (no-till, chisel, and moldboard), cover crop (hairy vetch and no hairy vetch), and nitrogen fertilization (0, 80, and 160 lb/acre) on tomato yield and nitrogen uptake, root growth, and soil carbon and nitrogen levels in central GA for two years. Chisel was used as minimum tillage and consisted of harrowing (4 to 6 in depth), followed by chiseling (8 to 10 in depth) and leveling (3 to 4 in depth). Similarly, moldboard was used for conventional tillage and consisted of harrowing, followed by moldboard plowing (8 to 10 in depth) and leveling. Hairy vetch fixes nitrogen from the atmosphere and was used to reduce N fertilization and N leaching. It was planted in the fall after summer crop harvest and killed by spraying Round-Up in no-till or incorporated into the soil in chisel or moldboard before tomato planting in the spring.

Inorganic nitrogen is the available form of nitrogen in the soil for plant uptake. Mineralizable nitrogen is a labile portion of organic nitrogen that will be mineralized and available during a growing season. Similarly, mineralizable carbon is a labile form organic carbon indicating microbial activities and can influence on N availability in the soil. Organic carbon and nitrogen are important components of organic matter where carbon and nitrogen are conserved in the soil.

Tomato yield and N uptake were lower in no-till than in moldboard but were similar in chisel and in moldboard. In contrast, tomato total number of roots from 1 to 22.5 in depth was greater in no-till than in moldboard and in no hairy vetch with 160 lb nitrogen/acre than in hairy vetch with 0 lb nitrogen/acre. Similarly, mineralizable nitrogen, mineralizable carbon, organic carbon, and organic nitrogen were greater in no-till or chisel than in moldboard at 0- to 4-in depth but were greater or similar in moldboard than in no-till or chisel at 4- to 12-in depth. Because of higher N concentration and accumulation, hairy vetch increased inorganic nitrogen, mineralizable nitrogen, tomato yield, and nitrogen uptake compared with no hairy vetch. Similarly, 80 and 160 lb nitrogen/acre increased inorganic nitrogen, mineralizable nitrogen, tomato yield, and nitrogen uptake compared with 0 lb N/acre. Inorganic and mineralizable nitrogen at 4- to 12-in depth and tomato yield and N uptake, however, were similar with 80 and 160 lb nitrogen/acre. Higher rainfall increased tomato yield and N uptake in 1997 than in 1996 but warmer weather promoted tomato root growth and mineralized more C and N in 1996 than in 1997. The results indicate that minimum tillage, such as chisel, with hairy vetch cover cropping and 80 lb nitrogen/acre should be practiced for sustained tomato productivity and improved soil and water quality.

See this full paper and its tables and figures in the Reviewed Papers Section of this Proceedings.

CROP SEQUENCE EFFECTS ON THE PROPERTIES OF A HAPLUDOLL UNDER CONTINUOUS NO-TILLAGE MANAGEMENT

M. Díaz-Zorita[1,2] and J.H. Grove[2]

AUTHORS: [1]INTA Gral. Villegas, CC 153 (6230) Gral. Villegas (BA), Argentina. E-mail: mdzori2@pop.uky.edu ; [2]University of Kentucky, Department Agronomy, N-122 Agriculture Science Center North, 40546-0091, KY, USA.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*, Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTRODUCTION

The most frequently cropped soils in the western part of the Pampean Region of Argentina are Mollisols. They are deep sandy to sandy-loamed, well-drained, with low to medium organic matter contents and low water storage capacity. The organic matter content in the top layer has been described as the soil property that is most related to the yields of the principal crops of the region. This soil property plays a key role in these soils through its regulation of water and nutrient supply and in maintenance of stable soil structure. The use of no tillage systems is increasing in this area because of the advantages of this system, which are mainly related with organic matter conservation, improvements in water infiltration and storage, and reduced soil erosion.

The literature is extensive regarding the effect of tillage and residue management on soil organic matter and resulting changes in soil physical and chemical properties. Tillage can mask crop rotation responses and rotation can alleviate potential adverse effects of reduced tillage on certain soils. However little is known about the contribution of different crops and cropping sequences to soil properties under continuos no-tillage management. The total amount of residue deposited, its composition, and its resistance to complete mineralization varies among plant species and can interact in a complex way with crop sequence and tillage practice. Plant materials with a high C: N ratio (corn, wheat) and high yields may be preferable in order to accumulate organic matter in these soils.

The objective of this study was to identify the effects of several corn-based crop sequences on the properties of an Entic Hapludoll under continuos no tillage management.

MATERIALS & METHODS

Field plots were established near Daireaux, Buenos Aires (Argentina), in 1994, on an Entic Hapludoll (clay = 13.1 %, silt = 11.0 %). We used a completely randomized design of 16 plots (6.2 acre each) containing the following 4 crop sequences:

A= Wheat/Soybean - Corn - Sunflower - Corn
B= Corn - Sunflower - Corn- Sunflower
C= Sunflower - Corn - Soybean - Wheat/Corn
D= Soybean- Wheat-Grazing Oats/Sunflower-Corn

The no-tillage management of the plots consisted only of chemical weed control immediately after the harvest of the crops, during fallow, and then in the growing season of the crops. Wheat crops were sown in early July, oat in March, corn and sunflower crops in October, soybean in November and corn or soybean as double crops after wheat harvest in December. Fertilizers were applied only for corn crops (45 lb. acre-1 of DAP and 90 lb. acre-1 of urea). The oat crop was grazed directly with stacker cattle during winter.

After the harvest of crops in the fall of 1998 composite soil samples were taken at the 0 to 2 and 2 to 6-in depths. The following analyses were performed on the air-dried soil samples: organic matter (Walkley and Black), available phosphorus (Bray Kurtz 1) and pH in water (1:2.5 ratio). The total amount of organic matter in each layer was calculated from the product of the sampled depth and the bulk density (Uhland sampler). All the soil properties were subjected to correlation analysis and ANOVA in two factor (crop sequence and depth) and means were separated by the LSD (T) significance test.

RESULTS & DISCUSSION

Although significant interactions due to the sampled depth and the crop sequence were observed, the soil organic matter (SOM), phosphorous (P) and pH levels were generally higher in the 0 to 2-in layer than in the 2 to 6-in layer. The opposite behavior was found for the bulk density values, likely related to the lesser amount of organic matter at the deeper depth. Most of the differences in soil properties due to the crop sequence were observed in the 0 to 2 in layer. The high P requirement of the sunflower crop and the lack of P fertilization of this crop, explain the low available P in treatment B (Table 1).

We observed that increasing the frequency of corn and wheat in the crop sequence (treatments A and C) caused the level of stored SOM in the 0 to 6 in layer of the soil to be higher than that observed in the other sequences (Fig.1). This behavior can be ascribed in part to higher residue yield from corn and faster decomposition of soybean or sunflower residues. The grazing effect may also have had negative consequences on organic matter accumulation.

The SOM levels did not correlate with the BD values and we assume that the lack of relationship between both properties can be attributed to the random effect of traffic and the texture of the soil (sandy-loam).

From these results we conclude that crop sequences including corn and wheat components are beneficial for rapid SOM accumulation in Entic Hapludolls from subhumid temperate regions.

Table 1: Effects of 4 crop sequences on soil organic matter (SOM), available P (Bray Kurtz 1) and bulk density (BD) levels.

Crop sequence	0 to 2 in. Depth				2 to 6 in. Depth			
	SOM	P	pH	BD	SOM	P	pH	BD
	%	ppm		Mg m-3	%	ppm		Mg m-3
(A) W/S-C-Su-C	3.55 ab	20.9 a	6.47 a	1.32 a	2.81 a	7.7 c	6.32 a	1.32 a
(B) C-Su-C-Su	2.97 b	17.5 b	6.58 a	1.29 b	2.67 a	9.2 bc	6.35 a	1.34 a
(C) Su-C-S-W/C	4.12 a	20.7 a	6.46 a	1.29 b	2.60 a	12.8 a	6.08 b	1.32 a
(D) S-W-o/Su-C	3.10 b	22.8 a	6.47 a	1.29 b	2.11 b	10.8 b	6.07 b	1.32 a

Columns followed by the same letter are not significantly different (Tukey, $p<0.05$).

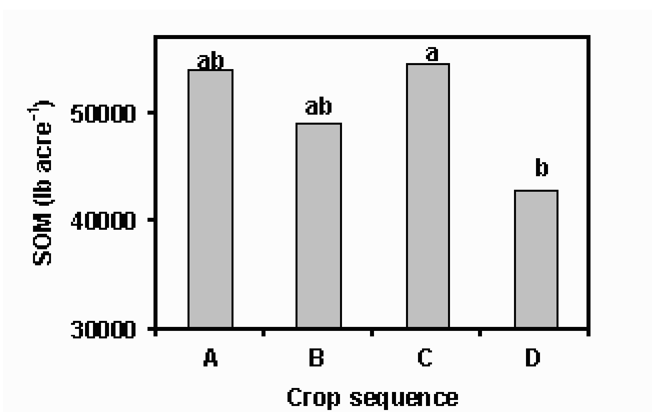


Fig.1: Soil organic matter content (0- 6 in depth) under 4 crop sequences grown on a Entic Hapludoll under continuos no tillage management. Bars topped by the same letter are not significant different.

NEMATODE POPULATIONS ON ROUNDUP-READY COTTON IN FLORIDA

R. McSorley[1] and R. N. Gallaher[2]

AUTHORS: [1]Entomology and Nematology Department and [2]Agronomy Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL. P.O. Box 110620, University of Florida, Gainesville, FL 32611-0620; email: rmcs@gnv.ifas.ufl.edu
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTERPRETIVE SUMMARY

The use of cotton varieties tolerant to the herbicide Roundup is increasing in the southern United States. However, as the use of new varieties increases, so does the potential for buildup of pest problems characteristic of those varieties. Three experiments were conducted in north central Florida during 1997 and 1998 to examine the buildup of plant-parasitic nematodes on Roundup-ready cotton varieties. In general, the buildup of plant-parasitic nematodes on Roundup-tolerant and Roundup-intolerant cotton varieties was similar. The various kinds of nematodes which occurred in these cotton crops are discussed in detail.

See this full paper and its tables and figures in the Reviewed Papers Section of this Proceedings.

INFLUENCE OF NITROGEN LEVELS ON COTTON PLANT/INSECT INTERACTIONS IN A CONSERVATION TILLAGE SYSTEM

D. M. Olson[1], S. C. Phatak[2] and W. J. Lewis[1]

AUTHORS: [1] USDA-ARS, Insect Biology and Population Management Research Laboratory, P. O. Box 748, Tifton, GA 31794, [2]University of Georgia, 100 Horticulture Department, Coastal Plain experiment Station, Tifton, GA 31794. Corresponding author: D. M. Olson, Email: dolson@tifton.cpes.peachnet.edu

REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens. GA.

INTERPRETIVE SUMMARY

A total system approach to pest management requires that we consider crop plants as active components of multi-trophic interactions. Plants can have both direct and indirect defenses against herbivores and pathogens and these defenses can be affected by plant nutrition and other environmental factors. Examples of direct defenses are production of toxins or digestibility reducers, or through physical defense by trichomes or toughness, or by a combination of the two, as with glandular trichomes or resins. Indirect defenses are when a plant benefits from the natural or applied enemies of herbivores. Indirect defenses may be brought about by the attraction of the natural enemy species to damaged plants that have been induced to produce and emit volatile chemical signals in response to herbivory. Evidence from a field test of induced resistance to herbivores and plant fitness, indicate that previous damage by herbivores decreases subsequent herbivory and enhances the seed mass of radishes. This field test did not examine plant nutrition effects on herbivory and plant fitness, and recent studies indicate that these can have a large effect on a plant's ability to produce direct and indirect defenses against herbivory. Recent evidence suggests that high nitrogen levels decreases the release of induced chemical volatiles from damaged cotton plants and the subsequent attraction to these plants by *Microplitis croceipes* (Cresson) a parasitoid of major cotton pests, *Helicoverpa zea* (Boddie) and *Heliothis virescens* (Boddie). In addition, although these cotton plants maintained their ability to produce antifeedants under all nitrogen levels tested, the high nitrogen plants received significantly higher leaf area damage than low nitrogen plants. Thus, awareness of plant effects on multi-trophic systems is essential in integrating plant breeding and biological control using natural enemies.

Experiments were conducted to test the effects of various nitrogen levels in a cotton field conservation tilled with plants previously damaged and not previously damaged by *Spodoptera exigua* (Hübner) larvae on the abundance of pests and predators, fruit production and damage, and total plant yield. A more focused study involving fitness effects of species showing strong response to these treatments will be the subject of subsequent field studies.

There was a general pattern of increasing numbers of *H. zea* and *H. virescens* eggs with increasing nitrogen. In addition, previous plant damage had a significant effect on the number of eggs found only at the higher nitrogen levels. As a result of these ovipositions, the larvae of these species also follow this general trend. It is not clear what the mechanism(s) is that allows for increased presence of these species on damaged plants in high nitrogen plots. Predation/parasitism of eggs and larvae may be lower on high nitrogen plants that had been previously damaged, and/or moths may be responding to differences in the chemical/visual properties of high nitrogen plants that had been previously damaged. Plants were taller in the highest nitrogen plots and previous reports indicate that several lepidopteran species prefer to lay their eggs on taller plants with high nitrogen. However, this cannot explain the preference for the previously damaged over the previously undamaged plants. If we assume that high nitrogen plants in our study were compromised in their ability to attract natural enemies and of moths to detect the previous damage, then oviposition should have been similar on damaged and undamaged plants. If higher nitrogen plants that had been previously damaged are not so compromised, then we would expect parasitism of eggs and larvae to be higher and that adults would avoid laying their eggs on these 'activated' plants. We did not assess predation/parasitism of eggs and larvae in this study and the eggs had not hatched at the final sampling. Further investigations of *H. zea* and *H. virescens* responses to higher nitrogen and previously damaged plants and the effect on their survival will be the subject of subsequent studies.

Aphids increase in numbers with nitrogen but at the highest nitrogen levels they begin to decline producing a dome shaped distribution across nitrogen amounts. The distribution of fire ants closely followed that of aphids. It may be that aphids respond to nitrogen in a linear manner and that the population on the highest nitrogen plots began to crash at an earlier date. Aphids did not respond to previously damaged or undamaged plants across the nitrogen levels examined.

Total fruit production and damage was highest in the plots with the highest nitrogen, but neither fruit production or damage was influenced by previous plant damage by *S. exigua*. The yield across all nitrogen levels, even in the plots where no nitrogen was applied (crimson clover only) were not significantly different.

Lacewing eggs follow the same pattern as *H. zea* and *H. virescens* eggs and larvae. More lacewings eggs were found on higher nitrogen plants that had been previously damaged. As a result of these ovipositions, the number of larvae and pupae of these species also follow this trend. Very few lacewing larvae or pupae were found throughout the season compared to the number of eggs that were found. Lacewing eggs hatch in 3-4 days which suggests high larval and pupal predation early in the season. The lacewing eggs found later in the season had not hatched at the time of final sampling. Therefore, further investigations of lacewing responses to higher nitrogen and previously damaged plants and the effect on their survival will be the subject of subsequent studies.

There was a strong interaction between nitrogen, previous plant damage and the insect species present with a general pattern of increased fruit damage on higher nitrogen plants. Based on an earlier study showing that plants could improve their fitness through previous damage by attracting parasitoids of the pest species, we would expect to find decreased oviposition on previously damaged plants. We found higher oviposition in the case of *H. zea* and *H. virescens* and lacewings. However, this preference was more the case with high nitrogen, thus indicating that the nature of plant signals may have been altered by nitrogen rates in such a manner that the pest perceives a weakened plant and the predator perceives higher numbers of prey.

See this full paper and its tables and figures in the Reviewed Papers Section of this Proceedings.

THE USE OF PLANT MAPPING FOR EVALUATING STRUCTURE AND YIELD OF SOYBEAN PLANTS

Terry Keisling[1] and Paul Counce[2]

AUTHORS: [1] Northeast Research and Extension Center, University of Arkansas, P.O. Box 48, Keiser, AR 72351; [2]Rice Research and Extension Center, University of Arkansas, P.O. Box 351, Stuttgart, AR 72160. Corresponding author Terry Keisling, Email: tkeislin@comp.uark.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTERPRETIVE SUMMARY

Many crop growth responses have been observed over the years. "Experience" is the knowledge obtained in working and observing the crop for years. Recently, the use of plant mapping in cotton has provided a means to document cotton growth responses. This has led to crop monitoring to follow the progress of the crop and identifying when unwanted growth patterns occur. This knowledge is subsequently used to manage the crop. In cotton, this technique has been so successful that it has essentially been adapted world wide. Few new cotton publications can be found where the technique is not used for some sort of crop development documentation.

Research Question

Would a general scheme for plant mapping be used with soybeans to aid in the interpretation and understanding of plant growth characteristics?

Several agronomic situations were mapped. They included planting in wheat stubble, growing the crop on shallow soil, lodging, cultivar growth habits, spacial population dynamics, row-spacing, and drought. The use of plant mapping techniques showed dramatic differences in plant growth responses. It appears that plant mapping will be a powerful analytical tool as well as a management tool for the soybean crop.

See this full paper and its tables and figures in the Reviewed Papers Section of this Proceedings.

VARIETY RESPONSE OF STRIP-TILL COTTON INTO WINTER COVER CROPS AT GAINESVILLE, FLORIDA

R.N. Gallaher[1]

AUTHOR: [1]Professor of Agronomy, PO Box 110730, Agronomy Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611-0730; E-mail: rng@gnv.ifas.ufl.edu. No endorsements or registrations implied herein.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*. Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTERPRETIVE SUMMARY

Upland cotton is an alternative crop to support Florida farmers. The objective of this research was to determine best yielding varieties for strip-till cotton in three different cropping systems. Data show that 2.75 bales/acre of lint cotton can be produced by some varieties in north Florida using strip-till management. Five of the glyphosate tolerant varieties were among the top yielding. Sites with a long history of growing rye as the winter crop provided best yields in double cropping systems. Consideration should be given to greater precision in determining percent lint when comparing yield among varieties. Nitrogen concentrations in diagnostic leaves should be in the range of 4.50 % to 5.00% for these high yielding glyphosate tolerant varieties in order to maximize lint and seed yield. Some unknown factor resulted in cotton yield being lower at sites with long histories of growing crimson clover and hairy vetch compared to rye.

See this full paper and its tables and figures in the Reviewed Papers Section of this Proceedings.

PUTTING RESEARCH ON THE FARM: THE SUSTAINABLE AGRICULTURE RESEARCH & EDUCATION PROGRAM

Jeffery L. Jordon

AUTHOR: Professor, Department of Agricultural & Applied Economics, University of Georgia, and Director, Southern Sustainable Agriculture Research & Education. Correspondence: Georgia Experiment Station, Griffin, GA 30223.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Combining on-farm research and sustainable agriculture principles, the Southern Sustainable Agriculture Research & Education program (S-SARE) has provided grants directly to farmers as part of its Producer Grant Program. In addition to the Producer Grant Program, S-SARE requires that its research and education grant recipients provide means and methods for farmer involvement and end-user outreach. This presentation will provide an overview of the S-SARE on-farm research program.

THE SARE PROGRAM

SARE is a national competitive grant's program with regional leadership and decision making structures. The program has offices in four regions of the U.S., recognizing the differences and diversity of U.S. agriculture. Authorized by the 1985 Farm Bill, SARE was first funded in 1988. In the first ten years, SARE funded 1,200 projects, spending $80.6 million. For each year approximately $11 million is divided among the four regions. The Southern SARE region comprises the 13 states as well as Puerto Rico and the U.S. Virgin Islands. SARE provides funding for research, demonstrations, education, and extension projects carried out by scientists, producers, educators and private sector representatives.

SARE's mission is to increase knowledge about – and help farmers and ranchers adopt – more sustainable practices that are profitable, environmentally sound and beneficial to local communities and society in general. Sustainable agriculture, as defined by Title XVI, Subtitle A Sec. 1603, consists of integrated systems of plant and animal production practices having site-specific applications that satisfy human food and fiber needs, enhances environmental quality and the natural resource base, make the most of nonrenewable resources and on-farm resources, integrates natural biological cycles and control, sustains economic viability of farm operations, and enhances the quality of life for farmers, ranchers, and society.

Southern SARE has evolved a set of principles that guides the research process. First, S-SARE is participatory: farmers are involved in all facets of S-SARE, as advisors, evaluators, and cooperators. Farmers help to design and conduct on-farm research. S-SARE is inclusive, from decision making to the conduct of research. The goal is to broaden the scope of agricultural research. S-SARE also addresses the needs of limited resource farmers and farmers with small holdings who are often overlooked in traditional agricultural research programs. S-SARE encourages a multi disciplinary-team approach to research, recognizing that agricultural sustainability requires a true multi- and inter-disciplinary approach. Consequently, S-SARE has developed a systems research method which is problem focused and accounts for the dynamic nature of agriculture.

In essence, S-SARE recognizes that agriculture is socially, economically and ecologically diverse with a large number and variety of stakeholders. The grants program, therefore, seeks to incorporate diverse scientific disciplines, difference types of institutions and organizations, farm households, and farm workers/managers/firm/consumers and communities. The goal is to encourage a diverse array of projects which provide critical information and insight on sustainability to multiple stakeholders who have a direct investment in project outcomes. The program seeks to build institutional and collaborative capacity so that problem solving becomes more flexible, participatory, inclusive and applicable.

One of the unique features of the S-SARE approach to sustainable agriculture research is the inclusion of farm-household members and farm workers in the research process. Rather than constructing research designs and farming recommendations in isolation from producers, agricultural researchers should consider that the research process and the production process are parts of one system. How and why farm-household members and other farm-level workers farm in particular ways are important to discern if university and government researchers wish to offer effective alternatives. In addition, the insight of people involved in the day-to-day work and management of the farm and farm household is essential for understanding the interaction between parts of production systems.

S-SARE GRANT CATEGORIES

S-SARE has four funding programs: Research & Education grants, Professional Development grants, graduate student awards, and Producer Grants.

A Producer Grant is a research, marketing or education project in the area of sustainable agriculture. Projects must be developed, coordinated and conducted by farmers and/or ranchers or a producer organization. Producer organizations should be comprised primarily of farmers/ranchers and must have majority farmer representation on their governing board. Producers or producer organizations complete a proposal describing their project and explaining how it will help other producers understand and adopt sustainable agriculture practices.

Producer Grant-funded projects generally involve research, marketing or education, although all kinds of innovative projects have received producer grants. Producer Grant marketing and education projects are generally designed to provide producers or producer organizations with information to implement sustainable agriculture practices. Other activities eligible for funding from the Producer Grant program include farm demonstrations, farmer workshops, farmer surveys and farmer-to-farmer networking activities that promote sustainable agriculture. Projects should be innovative, generate results that are useful beyond one year and generate results that many farmers can adopt. S-SARE has set aside $150,000 each year for Producer Grants. Grants have a cap of $10,000 for each project.

In addition to Producer Grants, the S-SARE's main granting effort is the Research & Education program. Approximately, $1.3 million is distributed yearly. For each R&E projects, S-SARE encourages substantial farmer and end-user involvement in all phases of the project.

Since the Producer Grant program began in 1994, 105 projects have been funded. Since 1988, S-SARE has also funded 120 R&E grants. For more information on the S-SARE program, see our web site at:
www.griffin.peachnet.edu/sare.

ON-FARM RESEARCH AND DEMONSTRATIONS USING CONSERVATION-TILLAGE IN GEORGIA

Glen Harris[1], Rick Reed[2], Randy Roberts, Andy Page, Daniel Lavender, Mark Van Waldner and Ben Tucker

AUTHORS: [1]Assistant Professor, Crop and Soil Sciences Department, University of Georgia, RDC Building, P.O. Box 1209, Tifton, Georgia, 31793; [2]University of Georgia, Cooperative Extension Service, Douglas, GA 31533. Corresponding author Glen Harris, Email :gharris@arches.uga.edu
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTERPRETIVE SUMMARY

The overall objective of gaining a better understanding of cover crops and conservation-tillage was met in these studies and therefore can be considered a successful project as a whole. Results from the cover crop screening emphasized the strong and weak points of each cover crop for use in a conservation-tillage system. Rye produced the most biomass, or residue, but legumes produced more nitrogen. However, in both studies where different N rates were applied to both rye and legume cover crops, the effect of cover crop was not significant. In other words, cotton yields increased with increasing N rate regardless of which cover crop was used. It appears that the addition of 30 to 60 lb/a of sidedress N, depending on the fertility history of the field and nematode pressure may optimize cotton yields. Although nematodes were not reported in this study, samples were taken and there are some indications that Cherokee Red Clover and Cahaba White vetch do not suppress nematodes as expected, and that rye may be the best cover crop to help keep nematode levels in check. Also, the earliness of maturity of AU Robin Crimson Clover and AU Early Cover Vetch make them good choices as legume cover crops for conservation-tillage system using cotton. The optimum planting window for cover crops also seems to be from around the first of October to the end of Thanksgiving. Planting cover crops in December or later should be avoided if possible to maximize biomass and N production and avoid possible winter kill.

Future studies already implemented on-farm using cover crops in conservation-tillage include documented effects on nematode populations and the need for fertilization, especially N on small grain cover crops. Studies involving grazing of cover crops and then the effect on subsequent summer crop yields are also needed as well as documentation of the long term effect of cover crops and conservation-tillage on soil organic matter levels and nutrient stratification.

See this full paper and its tables and figures in the Reviewed Papers Section of this Proceedings.

ADOPTION OF CONSERVATION TILLAGE IN COFFEE COUNTY

Rick Reed[1]

AUTHOR: [1]University of Georgia, Cooperative Extension Service, Douglas, GA 31533.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*. Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

I have been asked to speak today about how the adoption of conservation tillage and the use of cover crop production systems evolved in Coffee County. This was not the result of tremendous foresight or wisdom on the part of any one individual, least of all me. It did all start with a need, or several needs actually, but then one thing just sort of led to another until much to our surprise we have become known as leaders in the field.

It's hard to remember exactly what happened first, but to the best of my recollection it all started when a small group of growers (C. Deen, L. Harper, C. Harper, T. Dorminey, and W. Fussell) came to me in the late 80's asking about alternative production systems that might reduce their production costs. Remember, the 80's had been tough on the bottom line for a lot of farmers. There were three factors threatening their future economic stability as well. First, crop production inputs were steadily increasing. Second, erratic market prices had resulted in variable (usually shrinking) profit margins. And third, growers were faced with ever increasing government regulations pertaining to highly erodible land, nutrient management, water quality, etc. Growers needed a practical and sustainable production system to address these issues.

I suggested that we visit the Coastal Plains Experiment Station in Tifton to look at some of the research work being done by Dr. Sharad Phatak. Dr. Phatak had been conducting research for several years on the use of cover crops and conservation tillage with vegetables, soybeans, cotton and peanuts. These growers were very intrigued by "Doc's" unique production philosophy and the research he had done. Thus, was born the Coffee County conservation tillage effort.

After much studying, discussing and rehashing we determined that a system utilizing planted winter cover crops and reduced tillage methods would be both practical and sustainable for our situation and would allow growers to reduce production inputs, minimize soil erosion and protect our streams, rivers and lakes. As county agent I felt obligated to try to work out some of the kinks, so to speak, so that growers would not be vulnerable to quite as much risk while implementing a new production system, and then to educate other growers about the benefits of the system and how to implement it.

We were very fortunate in Coffee County to have a new conservationist Natural Resources Conservation Service (NRCS), who was also very enthusiastic about developing a conservation tillage/cover crop production system. The NRCS staff worked closely with the extension, research and the growers throughout the development of this system.

Initially we concentrated our efforts on on-farm demonstration plots to evaluate various winter cover crops including wheat, rye, clover, vetches and various mixtures of these, as well as optimum planting dates. Our goal was to:

C Determine which winter cover crops can be used in a cotton production system and measure the amounts of biomass and nutrients that are contributed with each.
8. Establish the cotton crop using row-tillage or other conservation tillage that leaves at least 30% of the soil covered with plant residues.
9. Maintain living vegetation or sufficient cover to provide support for beneficial insects during transition to cotton.
10. Keep chemical intervention at a minimum through weekly scouting of predator-prey populations throughout the growing season to determine when pests were out of control.

As information was also deficient concerning nitrogen and potash recommendations for cotton production following cover crops in a no-till or strip-till system, an additional study was incorporated into our research to determine what changes should be made in nitrogen and potash recommendations following winter cover crops for subsequent cotton production.

Once we had a little experience under our belts and some research based information to share, we set out to educate other growers and the general public. To promote conservation tillage we:

-- Held 5 Coffee County field days (approximately 600 contacts)
-- Hosted 2 Georgia Conservation Tillage Alliance Annual Meetings / Field Days (200 contacts)
-- Conducted 3 Coffee County Fall Cover Crop Meetings (60 contacts)
-- Hosted a North Carolina NRCS Soil/Water Quality Work Group Meeting (24 contacts)
-- Met with U.S. Representative Bob Smith (then Chairman of the House Ag Committee) and U. S. Representative Saxby Chambliss (Georgia, District 8) in 1997 to highlight the importance of conservation tillage

in water and soil preservation (26 contacts)

-- Held numerous classroom and community 'shade tree' type grower meetings on beneficial insects and pest management in conservation tillage (85 contacts)
-- And in 1995 we organized the Coffee County Conservation Tillage Alliance. There are currently 58 members in the alliance.

I also spread the word through local radio programs, newspaper articles, our Extension newsletter, and one-on-one grower contacts.

As I mentioned earlier, the conservation tillage efforts and accomplishments in Coffee County have been a team effort between growers, Extension, Research and the Natural Resources Conservation Service in the county. It is a given that growers are not likely to adopt a new, unproven production system without some evidence that it will work and that their risk will be minimal. NRCS personnel in Coffee County recognized this concern and helped acquire a grant through the Seven Rivers R C & D office for $18,300 to purchase a no-till drill, a no-till and strip-till planter and trailer. This equipment was used to do on-farm demonstrations and could be leased by growers to try on their own farms with assistance from Extension and NRCS personnel if needed. I am fairly certain we would not have achieved the success we did with this project had that equipment not been available.

Speaking of success, let me share with you how far we have come with conservation tillage in Coffee County. In the 1980's Coffee County had one grower practicing conservation tillage on his 200 acre farm. Due to our cover crop research, farm demonstrations and many other educational activities, conservation tillage use has jumped to approximately 30,000 acres in cotton, peanuts, soybeans, corn, vegetables and tobacco. Some 8,000 to 10,000 acres of winter cover crops are planted annually into which summer crops are then planted using the no-till system. There are currently four no-till drills in the county and 45-55 conservation tillage planters.

In 1997 NRCS personnel determined that eight tons of topsoil per acre were saved through these conservation methods, the result being a savings of over 24,000 tons of soil. Besides just holding the soil in place, a conservation tillage/cover crop system improves the moisture holding capacity of the soil, results in less compaction of the soil, a higher nutrient content in the soil, and improved structure and tilth of the soil. By simply holding the soil in place, there is less sediment and chemical and fertilizer contamination in our surface water. By using this system we are able to reduce the amount of time, labor and fuel necessary to produce a crop because we don't have to make as many trips across the field. We can use less expensive equipment because less horsepower is required. We've been able to use less fertilizer and pesticides. And we have greater flexibility at planting and harvest. In 1997 our farmers using conservation tillage realized a 15-20% reduction in production costs. That's an estimated savings of somewhere between $1,012,550 and $1,350,000!

We are all excited about the future of the conservation tillage program in Coffee County and plan to continue our research and educational efforts in this area. We believe this approach is a more biologically and ecologically friendly system than conventional tillage and that it provides the potential for greater profit margins while helping farmers meet government regulations to reduce soil erosion and protect water quality. Our future efforts will focus on 1) soil health and quality, 2) cover crops and nematode reaction, and 3) the feasibility of using black oats and other crops as cover crops with emphasis on nematode and disease suppression qualities, allelopathic properties, and cold hardiness.

Before I close I would like to recognize the growers and cooperating agencies who have made our program so successful. The following growers have gone out of their way to help us provide research based information for the general good. It takes a special kind of farmer to be willing to plant 8 different cover crops in 100 different plots in one 50 acre field! Tom Batten, Max Carter, Charles Deen, Jim Deen , Tommie Dorminey, Wayne Fussell, Lamar Harper, Chris Harper, Mike Nugent and Mark Vickers are that kind of farmer.

A number of agencies have provided technical and/or financial assistance for this program. They include: the Coffee County Ag Council, the Coffee County Conservation Tillage Alliance, the Georgia Conservation Tillage Alliance, the Georgia Cotton Commission, NRCS of Georgia, NRCS of North Carolina, Seven Rivers R C & D out of Waycross, Georgia, UGA Cooperative Extension Service, UGA Coastal Plains Experiment Experiment Station in Tifton, USDA-ARS Coastal Plains Experiment Station also in Tifton., and numerous banks, chemical companies and farm supply companies.

I have intentionally been brief with my presentation to give you time to ask questions. I didn't go into the specifics of our research or what we would do different if we had the chance. Please feel free to ask any questions you might have about the conservation tillage/cover crop program in Coffee County.

NO-TILL IN THE NORTH CAROLINA BLACKLANDS: A CASE STUDY FOR FARMER-TO-FARMER EXCHANGE

Carl R. Crozier[1] and Sam Brake[2]

AUTHORS:[1]Assistant Professor, North Carolina State University Soil Science Department; [2]Manager, Open Grounds Farm, Inc. Corresponding author: C.R. Crozier, V.G. James Research & Extension Center, 207 Research Station Road, Plymouth, NC 27962, carl_crozier@ncsu.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

SUMMARY

Farm records are presented which describe no-till acreage and yields at Open Grounds Farm, Inc. in eastern North Carolina.

The soil types and management on this farm are representative of many grain and cotton farms in the Blackland region of northeastern North Carolina. This is not highly erodible land, but the farm expected no-till to reduce wind erosion as well as to reduce labor needs.

The farm exceeded its original goal of 50% of acreage in no-till. Increased yield and a firmer soil surface for vehicle traffic are perceived by the farm as the most significant advantages with no-till. Farm records suggest corn yields are generally slightly higher with no-till. Since initially most no-till soybean was double-cropped and most conventional till was full season, it is difficult to assess the yield affect of tillage on soybean yield. The size of the labor force required to plant the corn crop has decreased from 24 (for less than 12,500 acres prior to 1991) to 10 (for more than 15,000 acres now). Stratification of soil pH and nutrients has been noted, but this does not appear to be a cause for immediate concern.

No-till has the potential to maintain, and perhaps slightly enhance yields while reducing labor costs in this flat, wet region. It is a locally appropriate model for many farms in northeastern North Carolina, since it involves organic soils and the typical land development and drainage networks of this area.

See this full paper and its tables and figures in the Reviewed Papers Section in this Proceedings.

THE ESTABLISHMENT AND ROLE OF THE GEORGIA CONSERVATION TILLAGE ALLIANCE, INC. AND LOCAL CONSERVATION TILLAGE ALLIANCES

L. L. Black[1] and J. E. Dean[2]

AUTHORS: [1]Farmer and President, Georgia Conservation Tillage Alliance, Inc., 932 Tilmanstone Road, Millen, GA 30442 and Conservation Agronomist, USDA Natural Resources Conservation Service, Federal Building, Stop #207, 355 East Hancock Avenue, Athens, GA 30601, james.dean@ga.usda.gov.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia. Agriculture Experiment Station Special Publication 95. Athens, GA.

The use of residue management, also called conservation tillage, no-till, and strip-till, continues to increase in Georgia. We now have more no-till cotton than any other state in the U.S. and the use of these conservation practices to produce peanuts and other crops increases each year. Among the reasons farmers are switching to residue management are reduced soil erosion; fuel, labor, equipment, money, and time savings; equal or slightly increased crop yields; increased soil organic matter; improved soil quality; reduced runoff and increased water infiltration; restored productivity on eroded land; improved air and water quality; and improved wildlife habitat.

Research on this conservation practice is lacking in our state. Farmers developed many of the proven concepts and most successful methods and are very willing to share this information with their fellow man. Every farmer should not have to "invent the wheel" each time they want to begin using residue management practices. Therefore, the agricultural leadership in Georgia recognized a need for a united effort to provide timely information to farmers wanting to adopt crop residue management. An organization meeting for the Georgia alliance was held in December 1993. Soon thereafter, a Steering Committee was formed to develop the framework for a successful program. It was recognized early on that farmers should be heavily involved in this process. Also, commodity groups, grower associations, universities, researchers, agribusiness, and government agencies volunteered to participate.

During 1994, the Steering Committee met monthly to establish a solid foundation for the Georgia Conservation Tillage Alliance, Inc. (GCTA). A mission statement and name were selected. Bylaws were developed and the GCTA was incorporated. During the growth process, we received valuable guidance from representatives of the North Carolina alliance.

The GCTA members elect the Board of Directors at the annual meeting. Six of the board members must be farmers. The Board of Directors, who serve a three-year term, elects the officers of President, Vice-President, Secretary, and Treasurer.

Many outstanding activities have been and are being carried out by the GCTA and its members. Numerous conservation tillage field days, tours, demonstrations, field trials, meetings, and one-on-one consultations have been held. Members give programs on crop residue management on a regular basis. Farmers and others are welcome to visit member's farms to view the crop residue management systems first hand. Farmers from as far away as Argentina have visited some of our farms. Other activities of the GCTA include field trials on new cover crops; participation at the Sunbelt Agricultural Exposition and Farm S.M.A.R.T. Conferences; assistance to the CSRA Conservation Tillage Demonstration Farm; and the formation of local conservation tillage alliances. Local alliances such as the Coffee County CTA and the East Central Georgia CTA have been very instrumental in the widespread use of crop residue management.

In the past, crop insurance was not available on cotton and peanuts produced with no-till and strip-till. The GCTA was instrumental in getting this changed. Crop insurance is now available for both crops produced with conservation tillage.

Another major activity of the GCTA was the development of the "Soil Quality Card for Georgia". Farmers in consultation with the USDA Natural Resources Conservation Service (NRCS) designed the card. Farmers can use the Soil quality Card for Georgia to evaluate changes in soil quality on their farm as they are affected by the use of crop residue management and other practices.

The GCTA is a grass-roots movement, where homegrown good ideas, research findings, and information exchange are used to improve and sustain Georgia's agriculture and natural resources. The networking and farmer-to-farmer information exchange is helping to improve our state.

NEED FOR A SYSTEMS APPROACH TO COTTON PRODUCTION: A CROP CONSULTANT'S PERSPECTIVE

Alton I. Walker[1], Sharad C. Phatak[2], and W. J. Lewis[3]

AUTHORS: [1]Agricultural Consultant, 6319 Brown Road, Harlem, GA 30814; 2Professor, Horticulture Department, University of Georgia, P.O. Box 748 Tifton, GA 31793; Research Entomologist, USDA-ARS, Insect Biology and Population Management Research Laboratory, Tifton, GA 31793.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station. Special Publication 95, Athens, GA.

The largest challenge facing much of Georgia agriculture is the development of a new low input sustainable system agriculture system before the current industry driven one destroys our entire natural resource base and agriculture infrastructure system.

The industrial age of agriculture began in the 30's kicked into high gear after World War II, and has dominated American agriculture until the present time. During the early years of the system, inputs form of resistant pests, later in the 60's, off-site pollution surfaced as a major problem. Due to these problems were made to more developed for more host specific environmentally friendly, through expensive pesticides. IPM programs were developed for most crops to reduce cost, pollution and to delay resistance. The results have been a more intensive and expensive management system that continues to escalate inputs while out-puts have leveled off or possibly declined in recent years.

Large machines that could cover large areas in a short period of time were developed. Terraces, uncropped ditch banks and hedgerows were removed to accommodate these machines. The machines compacted the soil, thereby requires deeper tillage, and in turn larger tractors which compacted the soil even deeper. Deeper tillage alone led to a decrease in soil organic matter and increased soil erosion. Removal of hedge rows, ditch banks and terraces increased the rate of wind and water erosion and eliminated a major refugia for insects. Herbicides not only eliminated weeds and grasses in crops but they also reduced soil organic matter and ground cover, which led to an increase in soil erosion. New varieties were developed and selected under an umbrella of pesticides for yield and quality only. Inherent natural strengths of pest resistance were lost, leaving the plant dependent on pesticides as their main line of defense.

All these inputs from the industrial system initially provided huge gains at a very low cost, but each in its own way eventually contributed to a continuous and steady decline inherent strength resource base of agriculture.

In the mid 60's Burke county GA could be described as an agricultural garden with more than 150,000 acres of crop land that produced lush crops of corn, cotton, and soybeans. Relatively high yields and profits were being derived from still moderate additions of fertilizers and pesticides. These positive affects of industrial agriculture were short lived. By the late 70's the consequences of these ecologically unsound and non-sustainable practices had resulted a steady course of decline that continues to the present. Today this once proud agriculture Eden has lost 100,000 acres of crop land and has been relegated to the brink of ecological, social, and economic bankruptcy.

A vast majority of this acreage loss was for economic reasons and certainly a few for social reasons, however, virtually none of the losses can be attributed directly to environmental concerns with ecological side of the equation without first addressing the economic and social underpinning are doomed to failure. Thus, in seeking, effective alternatives we must not limit our consideration to environmental concerns, but should encompass economic and social issues.

Any completely sustainable agriculture system must, 1) be designed to address the social ills of rural America, 2) include a breeding program which emphasizes plant pest resistance as an integral of crop production, 3) reduce the adverse production affects of large modern machines, and 4) replace the current high input monoculture system with a low input sustainable polyculture system that utilizes natures checks and balance to control pests.

CSRA CONSERVATION TILLAGE DEMONSTRATION FARM: DEVELOPMENT AND OPERATION

Richard G. McDaniel[1], Ken Wandless[2], Eddie Mallard[3]

AUTHORS:[1]County Extension Coordinator-Burke County, University of Georgia,[2] Environmental Specialist-Monsnato/NutraSweet,[3] CSRA Conservation Tillage Farm Manager. Corresponding author: Richard G. McDaniel, P. O. Box 300, Waynesboro, GA 30830, rmcdan@uga.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

DEVELOPMENT

In 1996 representatives of the Burke County Extension Service, NutraSweet Company and Monsanto Ag Chemicals met to discuss the possibility of the development of a local farm to demonstrate conservation tillage and new technology developments. NutraSweet is Augusta company within Monsanto that has a Burke County land application program of their nitrogen-based by-product NutraSweet owned a farm in the county consisting of 350 acres of row crop land, 120 acres of coastal Bermuda grass hay and 170 acres in other uses. Commitments were obtained by interested parties to plan and set up the project.

ORGANIZATION AND MANAGEMENT

A board of directors was established to provide operation objectives and set goals for the farm. Representatives from the sponsors and cooperators as well as local farmers were chosen for the board. Crop objectives, conservation tillage goals and overall direction and operations are set by the board. Actual demonstrations and plot layouts and production decisions are made by the County Agent, board and farm manager. The initial development began in the fall of 1996, a farm manager was hired, minimal equipment bought or borrowed and cover crops and small grains established on 350 acres.

FINANCING/OPERATION

The farm was established from donated funds and support from Monsanto, NutraSweet and a land application company, BioGrow (the contractor for the NutraSweet by-product). Expansion in 1997 came with John Deere as a sponsor of equipment needs. NutraSweet provides the use of the farm and, along with Monsanto and BioGrow, more than $70,000 in annual operating funds. We solicited $80,000 in products and services for the annual operation in addition. In fall of 1998 we received more than $200,000 in grant funds from NutraSweet to irrigate 200 acres of the farm. Valley Irrigation and a local dealer supplemented the funds to provide new technology in irrigation equipment to maximize the efficiency of water use and delivery. Netafim Corporation cooperated in a subsurface drip irrigation project on the farm to irrigate 10.5 acres with drip tape. An Extension Engineer is cooperating on both projects to develop better irrigation efficiency data for Georgia farmers.

Operation direction, recommendations and crop production information are provided by the Burke County Extension Service. The farm is a supporter of the East Central Georgia Conservation Tillage Alliance and cosponsored the 1999 Annual Meeting of the Georgia Conservation Tillage Alliance. Crop proceeds are returned to the operation of the farm and improvements. Additional income is used to fund scholarships for students pursuing a career in agriculture or related fields. No cooperators in the project receive profits from the farm and its operation..

As a result of farm success, collaborative efforts have brought other agencies into farm activities including Burke County Extension Service, Natural Resources Conservation Service, Brier Creek Soil and Water District, Central Savannah River Area Rural Community and Development Council, USDA Agricultural Research Service, Georgia Department of Natural Resources and other supporting agencies. They provide the cooperation for operation and special activities of the farm. Researchers from The University of Georgia are involved in demonstration plots on the farm. The farm is a Monsanto Center of Excellence farm representing Georgia and the Southeast.

Long term sampling is ongoing for organic matter and nutrient levels to provide farmers with information of the effects of conservation tillage on improving coastal plain soils. USDA researchers with Agricultural Research Service in Watkinsville, GA and Florence, SC are cooperating on measures of soil properties on conservation versus conventional sites.

Tall Timber Research Institute in Tallahassee, FL is cooperating on a quail habitat study on the farm as related to conservation tillage and the effect on feeding and chick survival.

We are in the process of developing a newsletter to be sent several times a year on farm activities, demonstration results and economics. The candidate has developed a Web page for conservation tillage which will be maintained as a resource on conservation tillage and CSRA farm activities. Both activities are supported by funds from NutraSweet Corporation.

The farm plan consists of local crops in rotation with comparison strips of conservation tillage and conventional tillage. Crops include corn, cotton, peanuts, soybeans, wheat, rye and other speciality crops on a trial basis. While most of the fields are in strip tillage, there are some areas with no-till or conventional planting to provide comparison information on yield, economics, organic matter and weed control.

New technology is highlighted on the farm with transgenic crops, new varieties, new production practices, sub-surface drip irrigation. The relationship with Monsanto has provided access too much of the new varietal technology to demonstrate to farmers before it is commercially available.

The farm is open to the public daily and visitors are encouraged. An annual field day is held the third Thursday of July each year and special tours can be arranged. Farmer involvement is a central focus of the farm. The overall purpose is as a farm scale demonstration site to develop and share conservation tillage information.

COMMON POKEWEED CONTROL IN CORN AND SOYBEAN WITH A CONSERVATION TILLAGE CULTIVATOR

J. D. Green[1] and William W. Witt[2]

AUTHORS: [1]Extension Professor and [2]Professor, Department of Agronomy, University of Kentucky. Corresponding author: J. D. Green, N106 Agricultural Science Building-North, University of Kentucky, Lexington, KY 40546, jgreen@ca.uky.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Station Special Publication 95. Athens, GA.

Common pokeweed (*Phytolacca americana* L.) is of increasing concern to corn and soybean producers in Kentucky and surrounding states where no-tillage production systems are used. Appearance of this weed species and other perennial dicots in field crops in recent years has occurred as tillage has decreased. In the past, pokeweed was considered to be more of problem weed in pasture areas, fencerows, and other non-cropland sites.

Specific management practices to prevent and control common pokeweed in row crops are not discussed in the literature. Because of its growth habit and large, deep-rooted taproot, effective control opitions are very limited in no-till cropping systems. Therefore, this research was initiated to evaluate the effectiveness of a conservation-till cultivator for pokeweed management, yet minimize soil disturbance. Treatments included cultivation with or without a postemergence herbicide treatment.

Experiments were conducted in Kentucky corn and soybean fields where common pokeweed had become well established after several years of continuous no-till crop production. In-crop cultivation and postmergence herbicide applications were evaluated at each location resulting in treatments arranged in a split-plot design. The main plots consisted of postmergence herbicide treatments applied four to five weeks after crop planting and an untreated check. Each main plot was divided into two sub-plots that consisted of cultivation or no cultivation. Cultivation was conducted approximately one week following herbicide application and was performed with John Deere 886 Conservation Tillage cultivator set to a soil depth of 2 inches. The horizontal sweeps are designed to move through the soil below the surface with minimal disturbance of the surface residue. The width of the sweeps between the row varied depending on the crop row spacing.

Corn Studies:

Four replicated studies were conducted on three different farms in Kentucky during 1996 and 1997. Cultivation treatments without a herbicide 12 WAT(weeks after treatment) gave over 60% control at two locations and approximately 40 to 50% control at the other two locations. In general, acceptable control was observed between the corn rows where cultivation occurred, but overall visual ratings per plot were lower since no control was obtained in or near the crop row. Average common pokeweed height in the untreated check plots ranged from 66 to 76 inches measured at 12 WAT. Whereas, the average height of common pokeweed plants was reduced by at least 75% with cultivation at three locations and reduced 50% at one location.

Exceed herbicide alone or Exceed followed by cultivation were highly effective in suppressing common pokeweed growth. Pokeweed control 12 WAT was 75 to 85% with Exceed without cultivation in three studies, while control was 43% at the other location. Cultivation one week following the Exceed application did improve effectiveness at three locations compared to Exceed alone. Common pokeweed heights were reduced gently reduced either with a postemergence application of Exceed or with Exceed followed by cultivation. At two locations Exceed followed by cultivation further decreased average plant height compared to Exceed alone.

Banvel without cultivation provided 60 to 86% control 12 WAT. Banvel followed by cultivation did enhance common pokeweed control 4 WAT, but was not improved 12 WAT compared to Banvel alone at two of three sites. Except for one study, average plant heights between Banvel alone and Banvel followed by cultivation did not differ and were equal to those observed with Exceed treatments.

Corn grain yield tended to be greater in postemergence herbicide treated plots with and without cultivation compared to the untreated check plots. This indicated that if left uncontrolled common pokeweed has the potential to reduce corn yield. Cultivation treatments had no negative effect on corn grain yield at any of the sites compared to the uncultivated plots.

Soybean Studies:

Two replicated studies were conducted in 1996 by dividing the field site into two main plot areas. Therefore, the potential impact of the "burndown" herbicide application to control the existing vegetation present before crop planting, including common pokeweed, could be evaluated along with in-season treatment affects of

Synchrony "STS" with and without cultivation. At time of soybean planting one study was treated with Roundup Ultra (3 pt/A) and the adjacent study area with Gramoxone Extra (3 pt/A). Another experiment was conducted in 1998 to evaluate in-season applications of Roundup Ultra and Synchrony "STS" with and without cultivation.

The "burndown" treatment used at time of planting had little impact on the common pokeweed control observed in the 1996 crop season. Common pokeweed control was approximately 45% 5 WAT when cultivation was used without a postemergence herbicide treatment. As noted with corn studies, acceptable control was observed between the rows where cultivation occurred, but was obtained in or near the soybean row. Common pokeweed height 5 WAT was reduced nearly 80% with cultivation compared to the untreated plots. Treatments with Synchrony "STS" with and without a cultivation provided better pokeweed control than the cultivation only treatment.

Common pokeweed in the 1998 study was about 30% when cultivation was used without a postemergence herbicide. Average pokeweed height 4 WAT was reduced over 50% with cultivation (28 inches) compared to the untreated plots (63 inches). Treatments with Synchrony "STS" with and without a cultivation provided 72 and 52% control, respectively, which was greater than control obtained with the cultivation provided over 95% control throughtout the season. Soybean grain yield was also greater with Roundup Ultra treatments compared to untreated plots and Synchrony "STS" without cultivation.

CONSERVATION TILLAGE CONFERENCE
TILLAGE AND NITROGEN INFLUENCE ON COTTON

P. J. Wiatrak[1], D. L. Wright[1], F. M. Rhoads[1], S. Reed[2], and J. Pudelko[3]

AUTHORS: [1]North Florida Research and Education Center, Quincy, FL 32351-9529; [2]Florida A and M University, Tallahassee, FL; [3] Agriculture University Institute of Soil Culture and Plant Production, Mazowiecka 45/46, 60-623 Poznan, Poland.

REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95, Athens, GA.

INTERPRETIVE SUMMARY

The experiment was conducted during 1996 - 1998 on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) at the North Florida Research and Education Center, Quincy, FL. The objectives of this study were to determine optimum N rates for cotton, the impact of fallow, small grain and legume as winter covers on N requirements of cotton, and to compare N requirements in strip tilled cotton with conventional plantings.

The experiment was conducted during 1996 - 1998 on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) at the North Florida Research and Education Center, Quincy, FL. The treatments were applied tillage (Strip tillage vs. Conventional), winter cover (Fallow vs. Legume vs. Wheat), and N fertility rates on cotton (0, 60, 120, and 180 lb N/acre).

CONCLUSIONS

- Higher yields of cotton were obtained after crimson clover than wheat or fallow.
- Nitrogen application up to 120 lbs/A significantly increased lint yield of cotton.
- Cotton bolls were heavier in strip-till than conventional till, heavier after fallow than wheat with positive response to N rate of up to 60 lbs/A.
- Plant height was greater in strip-till than conventional planting and greater after crimson clover than wheat and fallow, and increased with increasing N rates on cotton.

See this full paper and its tables and figures in the Reviewed Papers Section of this Proceedings.

TILLAGE EFFECTS ON THE GROWTH OF REDVINE

E. C. Gordon[1], T. C. Keisling[2], and L. R. Oliver[3]

AUTHORS: [1]Research Specialist University of Arkansas Agriculture Experiment Station; [2]Professor of Agronomy, University of Arkansas; [3]University Professor, University of Arkansas; P. O. Box 48, Keiser, AR 72351.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95, Athens, GA.

Abstract. Redvine (*Brunnichia ovata*) is a perennial plant that can reproduce through seed and vegetative propagation. Its distribution is from south Illinois and Missouri to South Carolina, Florida, and Texas. It is capable of producing an extensive underground stem (rhizome) and root system, and it is a problem in many agricultural fields. Research has shown that deep tillage with a moldboard plow provides good control of redvine while other tillage methods, especially no-till, can increase redvine infestations. The morphology of redvine stem growth can account for these responses to different tillage practices.

The redvine with shallow tillage (2-4 in.) has a taproot system with adventitious buds at the top of the taproot. These buds give rise to underground rhizomes as well as above ground stems. Deep tillage with a moldboard plow severs the connection of the plant with its deep roots about 8 to 14 in. deep. If the resultant pieces of stem and root either freeze or dry, they will not survive. This leaves only the roots deeper than the plowing depth to regenerate. With no tillage, underground rhizomes become established right up to the soil surface and continue to grow below ground every year without pruning. As a result, redvine infestations seem to “explode” under no-till culture.

WEED MANAGEMENT PROGRAMS IN NO-TILL COTTON, PEANUT, AND SOYBEAN

M.W. Edenfield[1], R.N. Gallaher[2], B.J. Brecke[3], and J.A. Tredaway[4]

AUTHORS: [1]Professor, University of Florida West Florida Research and Education Center, Jay, FL. *Corresponding Author: M.W. Edenfield, P.O. Box 110500. University of Florida, Gainesville, FL 32611. E-mail: mwe@ufl.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*. Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication. 95, Athens, GA.

INTERPRETIVE SUMMARY

Weed control is often considered one of the major hindrances to the successful adoption of conservation tillage systems. The purpose of this research was to evaluate potential weed control programs in strip-till Roundup Ready cotton, strip-till peanut, and strip-till Roundup Ready soybean. These studies demonstrate that good weed control options are available while still realizing the many benefits of reduced tillage crop production. In each crop studied a sequential POST application was required for good season-long weed control. In the Roundup Ready cotton and soybean experiments two applications of Roundup Ultra provided excellent control, and Starfire plus Basagran AC followed by Cadre POST resulted in excellent weed control in the peanut. Control of weeds was positively related to yield for all three crops under investigation. While these results appear promising, additional data is needed to confirm findings and allow greater assurance for making extension recommendations.

See full paper and its tables and figures in the Reviewed Papers Section of this Proceedings.

TILLAGE AND FERTILIZER SOURCE EFFECTS ON NITRATE LEACHING IN COTTON PRODUCTION IN SOUTHERN PIEDMONT

M.L. Cabrera[1], D. M. Endale[2], D.E.Radcliffe[1,] J.L Steiner[3,] W.K.Vencill[1], L. Lohr ,and H.H Schomberg[3]

AUTHORS: [1]Crop and Soil Science Dept. University of Georgia, Athens, GA; [2]USDA-ARS, 1420 Experiment Station Road, Watkinsville, GA 30677; dendale@arches.uga.edu. ; [3]USDA-ARS, 1420 Experiment Station Road, Watkinsville, GA 30677; [4]Dept. of Ag. Economics, University of Geogia, Athens, GA.

REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*. Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTERPRETIVE SUMMARY

Problem

The contamination of water resources by nitrate from agricultural sources is a major health and environmental quality issue confronting the US today. The type of tillage, as well as fertilizer N source, rate, and usage may influence the movement of nitrate through the soil profile. Recent rapid growth in cotton acreage, continuing expansion of use of poultry litter as alternative fertilizer source, and increasing adoption of alternative tillage methods have the potential for water quality degradation in the Southeast. The objective of this study was to quantify and compare potential nitrate losses from cotton production managed under no-tillage and conventional-tillage systems and fertilized with poultry litter and ammonium nitrate.

Literature summary

There is a prevalence of elevated nitrate concentrations in surface water and groundwater in watersheds of intensive agricultural use. Water infiltration and preferential flow typically increase when tillage is reduced or eliminated increasing the risk of potential contamination for ground water level by soluble nutrients. Field studies, however, often provide wide-ranging estimates of the relative effect of contrasting tillage practices on nutrient leaching losses. Only limited data are currently available for the Southeast concerning the fate of nutrients under contrasting tillage treatments. Little is known about the possible interactions of tillage and poultry litter use in determining nutrient movement to ground and surface water.

Study Description

The experiment was conducted in 1997 and 1998 at the USDA-ARS J. Phil Campbell, Senior, Natural Resource Conservation Center, Watkinsville GA. The site consisted of 12 instrumented, tile-drained plots each 30 ft by 100 ft, located on nearly level (0-2%) slope Cecil sandy loam. Factorial combinations of two tillage and two fertilizer treatments each replicated three times was imposed. The conventional-tillage consisted of chisel plowing and disking while no-tillage consisted of coulter planter use only. Fertilizers were poultry litter applied at a rate of 2 tons/acre (30% moisture basis; equivalent to about 54 lb/acre available N), and ammonium nitrate applied as conventional fertilizer at a rate of 54 lb/acre available N. Rye was used as cover crop on all plots each winter and received 50 lb/acre available N as ammonium nitrate before planting. Tillage treatments started on the 12 plots in April 1992 in connection with another study. Stoneville 474 variety cotton was planted on May 14, 1997 and May 14, 1998. Harvest dates were November 4, 1997 and November 12, 1998. Pesticides and fertilizers were applied before planting and, in conventional-tillage plots, incorporated into soil by light disking immediately afterwards. There was no soil incorporation of pesticides and fertilizer in no-tillage plots. Drainage was measured by tipping buckets, and recorded digitally by data loggers. About 10 oz of the drainage flow was automatically collected after every 160 gallon flow and stored in the field in refrigerated samplers until taken to the laboratory for nitrate analysis.

Applied Question

Is there more nitrate loss in subsurface drains from cotton managed under no-tillage and fertilized with poultry litter compared to conventionally-tilled cotton fertilized with ammonium nitrate?

There was no difference in nitrate leaching between no-tillage and conventional-tillage treatments in 1997. Poultry-litter-treated plots had a total nitrate loss of 9.4 lb/acre N/A compared to 5.9 lb/acre N/A for ammonium-nitrate-treated plots. This difference between fertilizer sources is for all practical purposes non-significant and may have been due, at least in part, to a larger than expected N mineralization from poultry litter. In our calculation we had estimated that 50% of the organic N in poultry litter would be come available to the crop.

Before the application of N, nitrate concentrations in draining water were below 3 ppm in all treatments. During the first two months after N application concentrations increased to 20 or 30 ppm in the conventional-tillage plots and to 10 or 15 ppm in the no-tillage plots. Concentration in poultry litter treatments were up to 5 ppm larger compared to ammonium nitrate treatments. By late September, concentrations had decreased to about 5 ppm in the conventional-tillage and poultry litter treatments, and to about 1 to 3 ppm in the remaining treatments.

There was no significant drainage in 1998 and thus we collected little effluent. Rainfall was 7 inches below normal for May through November, with deficit in each month. Most events were well below 1 inch, the approximate threshold above which drainage was observed in 1997. From our observations so far, no-tillage did not increase nitrate leaching when compared to conventional-tillage. Although poultry litter led to a larger

Nitrate loss than conventional fertilizer, the difference between fertilizer sources was relatively small and for practical purposes non-significant. We report in another paper in these proceedings, that no-till produced 30% more lint compared to conventional till over three years. Also, yield from no-tillage-poultry-litter plots was almost 50 percent larger than that from conventional-tillage-conventional-fertilizer plots. These are encouraging results for those engaged in promoting no-tillage and poultry litter use in cotton production in the Southeast.

COTTON YIELD RESPONSE TO TILLAGE-POULTRY LITTER INTERACTIONS IN THE SOUTHERN PIEDMONT

D.M. Endale[1], D.E. Radcliffe[2], J.L. Steiner[3], M.L. Cabrera[2], D.V. McCracken[4], W.K. Vencill[2], L. Lohr[5], H.H. Schomberg[3]

AUTHORS: [1] USDA-ARS, 1420 Experiment Station Road, Watkinsville, GA 30677; dendale@arches.uga.edu; Crop and Soil Science Dept. University of Georgia, Athens, GA 30602; [3]USDA-ARS, 1420 Experiment Station Road, Watkinsville, GA 30677; [4]Consultant, 102 Hamilton Lane, Bremen, GA 30110; [5]Department of Agricultural Economics, University of Geogia, Athens, GA.
REFERENCE: J. E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July, 1999. Georgia Agriculture. Station Special Publication 95. Athens, GA.

Abstract. Cotton (*Gossipium hirsutum* L.) is a major crop in Georgia and is mostly grown under conventional-tillage with conventional inorganic fertilizers, such as ammonium nitrate. But reduced tillage is drawing increased attention nationwide as a viable production option. A growing poultry industry in Georgia is generating increased quantities of poultry litter, some of which can be used as an alternative organic fertilizer in crop production. This research was conducted to observe the performance and yield response of cotton planted with no-tillage and fertilized with poultry litter. Research was conducted for three years under a factorial arrangement of tillage (no-tillage vs conventional-tillage) and fertilizer (ammonium nitrate vs poultry litter) on a Cecil soil of Southern Piedmont near Watkinsville, GA. Lint yield from the no-tillage treatment exceeded that of conventional-tillage by about 30% (P=0.009) over three years. Yield from no-tillage, poultry litter-fertilized cotton exceeded that of conventional-tillage, ammonium nitrate-fertilized cotton by almost 50 percent (P=0.005). Cotton production in the Southern Piedmont could be improved by using no-tillage and poultry litter as fertilizer compared to conventional-tillage and ammonium nitrate as fertilizer.

INTRODUCTION

Reduced tillage as a production option is drawing increased attention nation wide. It promises to save producers money in the short term and provide long-term benefits for their land and the environment. Reduced tillage is credited with maintaining or increasing yield, reducing overall production costs, arresting or reversing soil degradation processes and reducing nutrient and pesticide losses by reducing runoff volume (increased infiltration) and soil loss (CTIC, 1992; Domitruk and Crabtree, 1997). However, much of the row-crop agriculture, including cotton, in the Southeast is based on conventional tillage. Georgia is a major cotton producing state in the Southeast. Area planted to cotton increased from about 315 000 acres in 1987 to about 1 425 000 acres in 1997 (Rodekohr and Rahn, 1997).

Experience is accumulating with regard to no-till production of cotton on the alluvial and loess soil of Arkansas, Louisiana, Mississippi, and Tennessee (Keisling et al., 1992; Kennedy and Hutchinson,1993). Much less is known about the performance of no-till cotton on the dominant agricultural soils of the Piedmont. Georgia is also experiencing a growing poultry agribusiness, currently worth $10 billion annually (Rodekohr and Rahn, 1997). The recent and projected growth in cotton acreage provides an outlet for efficient use of poultry litter as an alternative organic fertilizer. Little is known about the tillage-poultry litter interactions on soil water availability and cotton yield effects on Piedmont soils.

OBJECTIVE

Evaluate the performance and yield response of cotton under a factorial arrangement of tillage (no-tillage vs conventional-tillage) and fertilizer (poultry litter vs. ammonium nitrate).

METHODS

The experiment was conducted in 1996, 1997, and 1998 at the USDA-ARS J. Phil Campbell, Senior, Natural Resource Conservation Center, Watkinsville GA. The site consisted of 12 instrumented, tile-drained plots each 30 ft by 100 ft, located on nearly level (0-2%) slope Cecil sandy loam (Clayey, Kaolinitic thermic Typic Kanhapludults). The experimental design was a completely randomized block with a factorial arrangement of tillage and fertilizer. Each treatment combination was replicated three times. The conventional-tillage consisted of chisel plowing and disking while no-tillage consisted of coulter planter use only. Fertilizers were poultry litter applied at a rate of 2 tons/acre (30% moisture basis; equivalent to about 54 lb/acre available N), and ammonium nitrate applied as conventional fertilizer at a rate of 54 lb/acre (60 kg/ha) available N. Potassium was applied based on soil test results. Phosphorous was not applied as soil test results established no need. Rye (*Secale cereale* L.) was used as cover crop each winter. Tillage treatment had been imposed on the 12 plots since April 1992 but this study was started in 1996.

Stonville 474 variety cotton was planted on May 30, 1996, and May 14, 1997 in 34 inch rows at a rate of 3 to 4 plants per foot and harvested on November 1, 1996, and November 4, 1997, respectively. In 1998, cotton was planted on May 14 in 30 inch rows and harvested on November 12. Effective insect, weed and grass control was achieved with a combination of pesticides, and cultivation on conventional-tillage plots. Cotton pesticides were: Aldicarb (Temik), insecticide for control of thrips and nematodes at 4 lb/acre, Fluometuron (Cotoran), a broadleaf herbicide, at 2 pt/acre, and Pendimethalin (Prowl), a herbicide for control of annual grass and broadleaf weeds, at 1.5 pt/acre. Pesticides and fertilizers were applied before planting, and, in conventional-tillage plots, incorporated into soil by light disking immediately afterwards. There was no soil incorporation of pesticides and fertilizer in no-tillage plots. PIX was applied as a growth regulator at 8 oz/acre soon after bloom and 10 days later. Harvade and Prep at rates of 8 oz/acre and 1 pt/acre were used as defoliant and boll opener respectively.

Average soil moisture was measured in five segments (0-6 in., 6-12 in., 12-24 in., 24-36 in. and 36-48 in.) between two and three times a week over the growing season in 1998. A TDR-based Moisture Point System of Environmental Sensors Inc. (ESI, Victoria, British Columbia, Canada) was used for the measurement. Four plots (conventional-tillage-ammonium-nitrate, conventional-tillage-poultry-litter, no-tillage-ammonium-nitrate, and no-tillage-poultry-litter) were instrumented with two probes each and soil moisture readings were averaged. Data were organized such that changes from the previous reading were cumulatively added to give temporal net soil moisture change. Dry plant part weights for leaf, petiole, stem and bolls were determined on six randomly selected plants per plot just before harvest from the 1998 crop. Plants were sampled , separated into different plant parts, dried in an oven and weighed. Pant height and leaf area were also measured.

Yield data were analyzed as random complete block with a factorial arrangement of treatments, and repeated measures design using the MIXED procedure of SAS (Littell et al., 1996). A check on homogeneity of variances associated with treatments indicated that the no-tillage-poultry-litter treatment had a larger variance than the other treatment combinations. As a results, treatments were separated into two variance groupings and were included in the statistical analysis by using the grouping option on the repeated statement.

RESULTS

Lint yield

Treatment effects were consistent over the three years (figure 1). Lint yields from no-tillage plots compared to conventional-tillage plots were higher by 26.7, 27.5 and 35.8 percent (average 30 percent; P=0.009) for the three consecutive years, respectively. Yields from no-tillage-poultry-litter plots were higher by 43.2, 54.6, and 50.2 percent (average 49 percent; P=0.005) for the three consecutive years, respectively, compared to conventional-tillage-ammonium-nitrate plots. Yields were different between fertilizer treatments (P=0.078). Yields were not different among years (P=0.384). No interaction existed between combinations of fertilizer and tillage (P > 0.57).

Soil water use

Cumulative net soil moisture change between June 8 and November 4, 1998 is shown in figure 2.
Net soil moisture change was negative in all profiles indicating net soil water use. No-tillage plots had almost twice the total change of conventional-tillage plots in the 0-24 inch depth. About 68% of the change for no-tillage plots and 83% of the change for conventional-tillage plots occurred in the 0-24 inch depth.

About 22% of the change for no-tillage plots and 13% of the change for conventional-tillage plots occurred in the 24-36 inch depth. The greatest change for the no-tillage plots was in the 0-6 inch depth while for the conventional-tillage plots it was in the 6-12 inch depth. No-tillage-poultry-litter plots showed about 2.4 times more change than conventional-tillage-ammonium-nitrate plots in the 0-24 inch depth. The 1998 crop season was drier than normal and this was reflected in lower yields than in the other two years. No-tillage had the highest effect in 1998 indicating better use of available soil water.

Biomass

Differences in treatment effects were apparent not only in lint yield but in overall vigor of growth during the crop season. In general, cotton in no-tillage plots was taller and had more biomass by first bloom than cotton in conventional-tillage plots. The contrast was greater between no-tillage-poultry-litter and the other treatments. Results of the 1998 sampling are given in table 1. This table shows that plant height, leaf area index and average dry weights of petiole, leaf, stem and bolls were between 17 and 59 percent higher in no-tillage plots than in conventional-tillage plots (line 5). Differences were higher (39 to 97 percent) between no-tillage-poultry-litter and conventional-tillage-ammonium-nitrate treatments (line 6). The largest differences were for stems and bolls.

SUMMARY AND CONCLUSIONS

Yield of no-tillage cotton exceeded that of conventional-tillage cotton by approximately 30 percent over a three year period (P=009). Yields were almost 50 percent (P=0.005) greater from no-tillage-poultry-litter cotton treatment than from conventional-tillage-ammonium-nitrate treatment. The no-tillage treatment produced 50 percent more above ground biomass than the conventional-tillage treatment in 1998. And the no-tillage-poultry-litter treatment produced 72 percent more above ground biomass than the conventional-tillage-ammonium-nitrate treatment. Soil water use in the 0-24 inch depth was almost double for no-tillage compared to conventional-tillage cotton and about 2.4 times more in no-tillage-poultry-litter compared to conventional-tillage-ammonium-nitrate treated cotton.

The Southern Piedmont often suffers short-term droughts with detrimental effects on crop yield, despite abundant precipitation. Our research indicates that no-tillage enhances use of available soil water and can provide additional insurance against crop failure during drought-prone periods compared to conventional-tillage. More efficient soil water use also leads to greater yields in normal years. A combination of no-tillage with poultry litter fertilizer appears to enhance available soil water use even more than a conventional-tillage and ammonium nitrate combination and can provide even more insurance against crop failure and promote higher yields. Although most cotton in Georgia is grown under conventional-tillage using conventional fertilizers, such ammonium nitrate, production could be improved by adopting no-tillage and using poultry litter as fertilizer.

ACKNOWLEDGMENTS

Funding for the research came from the USDA Cooperative State Research Service NRICGP Water Resources Assessment Protection Program and the Southeast Egg and Poultry Association. We greatly appreciate the assistance by T. Foard, S. Noris, L. Robicheaux, B. Nutt, J. Doster, D. Stark, C. Bokey, R. Woodroof and students from the Crop and Soil Science Department of the University of Georgia.

REFERENCES

CTIC, 1992. National survey of conservation-tillage practices. Conservation Technology Information Center, West Lafayette, IN.

Domitruk, D. and B. Crabtree (ed.), 1997. Zero tillage: Advancing the art. Manitoba-North Dakota Zero Tillage Farmers Association, Minot, ND.

Keisling, T.C., M. McClellan and R.E. Frans, 1992. Reduced tillage for cotton production in Arkansas. p. 108-112. In M.D. Mullen and B.N. Duck (ed.) Proc. 1992 Southern Conservation Tillage Conf., Jackson, TN: 21-23 July 1992. Tennessee Agric. Expt. Sta.. Knoxville, TN.

Kennedy, C.W., and R.L. Hutchinson, 1993. Tillage and cover crop effects on cotton growth and development on a loessial soil. p. 72-76. In P.K. Bollich (ed). Proc. 1993 Southern Conservation Tillage Conf. for Sustainable Agriculture, Monroe, LA. 15-17 June 1993. Louisiana State University Agricultural Center, Baton Rouge, LA.

Littell R. C., G. A. Milliken, W. W. Stroup and W. R. Wolfinger. 1996. SAS systems for mixed models. SAS Inst., Inc., Cary, NC.

Rodekohr, J., and D. Rahn, (ed.), 1997. Georgi Agriculture 1996. Educational Support Services, University of Georgia Extension Service, Athens, GA.

Table 1. Average Plant Height, Leaf Area, and Biomass Dry Weight for 1998 for Six Randomly Selected Plants from Each of Conventional-tillage (Ct), No-tillage (Nt), Conventional-tillage-ammonium-nitrate (Ctan) and No-tillage-poultry-litter (Ntpl) Treatment Plots.

Treatment Plots	Plant Height inches	Leaf Area sq ft	Average dry weight in lb*			
			P	L	S	B
CT	22.9	9.27	0.015	0.132	0.273	0.677
NT	29.5	11.24	0.018	0.160	0.436	1.036
CTAN	22.5	7.94	0.014	0.121	0.236	0.625
NTPL	30.4	11.65	0.020	0.169	0.466	1.064
NT/CT	1.288	1.213	1.174	1.214	1.599	1.530
NTPL/CTAN	1.351	1.467	1.428	1.397	1.975	1.702

* P-petiole,; L-leaf; S-stem; B-boll

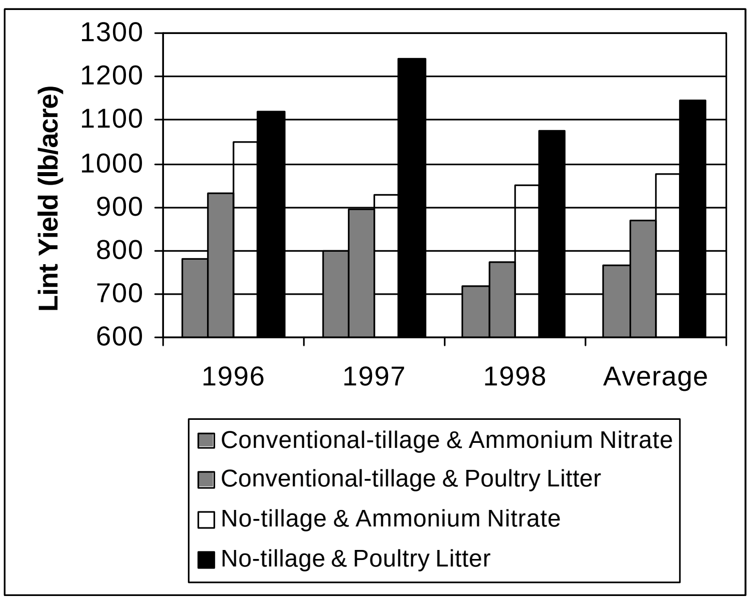


Fig. 1 Lint yield in lb/acre across treatments for 1996 to 1998

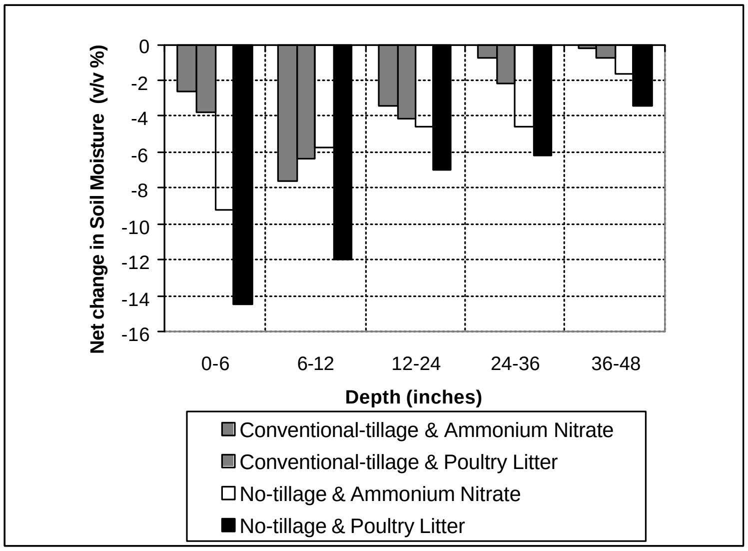


Fig. 2. Cumulative net soil moisture change between June 8 and November 4, 1998 for 4 plots of contrasting treatment.

USING DEEP TILLAGE TO IMPROVE YIELDS FROM DRYLAND SOYBEANS: AN ECONOMIC ANALYSIS

A. D. Pearce[1], C. R. Dillon[2], T. C. Keisling[3], C. G. Friddle[4], and M. P. Popp[5]

AUTHORS: [1]Reseach Specialist, Department of Agricultural Economics, University of Arkansas, 221 Agriculture Building, Fayetteville, AR 72701; [2]Associate Professor, University of Kentucky Department of Agricultural Economics, 403 Agricultural Engineering Building, #2, Lexington, KY 40546-0276; [3]Professor, University of Arkansas, Department of Agronomy, Northeast Research and Extension Center, P. O. Box 48 Keiser, AR 72351; [4]Technical Assistant, University of Arkansas, Department of Agricultural Economics and Agribussiness, 221 Agriculture Building, Fayetteville, AR 72701; and [5]Assistant Professor, University of Arkansas, Department of Agricultural Economics and Agribussiness, 221 Argiculture Building, Fayetteville, AR 72701, respectively.

REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*. Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTERPRETIVE SUMMARY

Problem

Is deep tillage an economically feasible method to increase yields of dryland soybeans?

Background

In the lower Mississippi River flood plain and loessial terraces, there are three primary soils i.e. alluvial clays, alluvial silt loams and loessial silt loams. Deep tillage on these resulted in consistent cotton yield responses on the alluvial silt loams but not on the clays and loessial silt loams. Other studies reported for soybeans in the region with deep tillage or in the row subsoiling gave no increase in grain yields. Many subsoiling studies on alluvial clay have been conducted over the years with erratic results. Consistent results have been reported for Tunica clay for subsoiling when the clay was dry.

Study Description

A complete list of tillage treatments consisted of (1) conventional shallow tillage twice to prepare a seed bed, (2) deep chiseling in fall to a depth of circa 15 cm when the soil was dry, (3) subsoiling in planting direction in fall when soil was dry with hyperbolic subsoiler to a depth 35 to 45 cm deep, (4) same as treatment (3) but at 45 degree angle to planting direction, (5)same as treatment (3) but performed in late winter or early spring when soil was wet. Treatments were arranged in a randomized complete block with 8 to 10 reps. The experiment was undertaken on Sharkey silty clay, Earle-Alligator-Sharkey Clay complex, Dubbs-Dundee silt loam complex, Alligator clay, Grand prairie silt loam, and Calloway-Calhoun-Henry silt loam complex. The studies were all nonirrigated with typical summer rainfall patterns for the region.

Applied Questions

Does subsoiling give economic responses on all soil types studied?

An economic resonse to deep tillage was obtained on alluvial soils, but not on loessial silt loams.

Is there an economic impact associated with the timing of deep tillage operations?

On average, superior net returns were obtained when deep tillage was performed when the soil was dry. Therefore it is more beneficial to perform deep tillage operations in the fall rather than in the late winter or spring.

See this full paper and its tables and figures in the Reviewed Paper Section of this Proceedings.

TILLAGE, ROTATION, AND N SOURCE INTERACTIONS ON CHEMICAL PROPERTIES OF AN APPALACHIAN PLATEAU SOIL

A. C. V. Motta[1], D. W. Reeves[2], and J. H. Edwards[2]

AUTHORS: [1]Agronomy and Soils Department, Auburn University; [2]USDA-ARS National Soil Dynamics Laboratory, 411 S. Donahue Dr., Auburn, Al 36832. Corresponding author A. Motta, Email: amotta@acesag.auburn.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTERPRETATIVE SUMMARY

Problem

Soil quality can be strongly affected by soil management. Adoption of conservation tillage, crop rotation, and use of animal manures have all been shown to improve soil quality in certain situations. However, studies including all three management practices are scarce and such knowledge is needed to better integrate crop and animal production systems. This study evaluated effects of these management practices on some chemical indicators of soil quality in the poultry-intensive Appalachian Plateau of northern Alabama.

Study Description

The study was established in 1982 on a Hartsells fine sandy loam in northeastern Alabama (fine-loamy, siliceous , thermic Typic Hapludult) and has as treatments rotations of corn (*Zea mays* L.) or soybean [*Glycine max* (L.) Merr.] following a wheat (*Triticum aestivum* L.) cover crop under conventional tillage and conservation tillage. The conservation tillage treatment consisted of planting directly into residue from the wheat cover crop that had been desiccated with paraquat each year. In some years the conservation tillage treatment was lightly disked (2 to 4 inches deep) in fall before drilling wheat. Conventional tillage consisted of a shallow disking prior to planting the wheat cover crop in the fall; followed by disking, chisel plowing (6 to 8 inch depth), and leveling with a disk in spring. Two N sources for the wheat cover crop; poultry litter and NH_4NO_3, were introduced as treatments in 1992. We assumed that the fall-applied litter supplied about 60 lb N/acre (67 kg N/ha) to the soil/plant system each year, based on extension recommendations that about 50% of the total N in poultry litter becomes available (is mineralized) the first year of application. Each year corn received 50 lb N/acre (56 kg N/ha) at planting and an additional 150 lb N/acre (168 kg/ha) as NH_4NO_3 2 to 3 weeks after emergence. Soil samples were collected in 1997 from the 0-1.2, 1.2-2.4, 2.4-4.8, and 4.8-9.6 inch depths (0-3, 3-6, 6-12, and 12-24 cm depths). The experimental field design was a split-split-plot design with four replications. Tillage, rotations, and source of wheat N fertilizer were main, sub, and sub-subplots, respectively. Sampling depths were analyzed as an additional split in the design. Analyses of variance was conducted on all response variables and mean separation was done with Fisher's protected least significant difference (LSD) values at the 95% level of confidence. Correlation, simple, and step wise regression were also used to analyze relationships among chemical soil quality variables.

Applied Question

How did tillage and rotation interact with poultry litter applications to change soil chemical properties?

Results presented in Table 1 indicate that soil organic carbon (SOC) was affected by the interaction of tillage, N source, and depth ($P \leq 0.05$). Poultry litter application increased SOC within the first 2.4 inches of soil only under conservation tillage. Under conventional tillage, litter increased SOC only between 1.2 and 2.4 inches, as a result of litter incorporation by shallow disking. Calculated SOC mass (using SOC concentration and bulk density) to the 9.6-inch depth with poultry litter application under conservation tillage was 3486 lb/acre, compared to 1664 lb/acre under conventional tillage. This increase can be attributed to increased residues under conservation tillage and/or C from the litter being retained with conservation tillage compared to conventional tillage. Soil organic carbon was also affected by a rotation x poultry litter interaction ($P \leq 0.01$)(data not shown). The concentration of SOC increased with the corn rotation (12.6 g/kg) compared to soybean (10.5 g/kg) when poultry litter was used. This was probably associated with greater residue production under corn as well as the wider C:N ratio of corn residue compared to soybean.

Like SOC, pH was also affected by tillage, N source, and depth. A higher soil pH between 1.2 and 4.8 inches was maintained under conservation tillage with poultry litter compared to conservation tillage with NH_4NO_3 ($P \leq 0.05$). The same trend was observed between 4.8 and 9.6 inches. However, poultry litter had no effect on pH under conventional tillage where lime and poultry litter were incorporated together. Rotation had a large impact on soil pH due to fertilization of corn with 200 N lb/acre. Nitrification decreased pH an average of 0.6 units within 1.2 and 4.8 inches under conservation tillage with the corn

system (data not shown).

Under conservation tillage, Ca concentrations were stratified, especially when litter was applied. Litter applications increased Ca concentration to the 4.8 inch depth under conservation tillage while under conventional tillage litter increased Ca concentrations only to the 2.4 inch depth. Calcium and K are the second most abundant plant nutrients in poultry litter. This, coupled with organic acid formation from decomposition of organic matter in crop residues and litter, offers an explanation for the increase in Ca deeper in the soil profile under conservation tillage compared to conventional tillage. Organic acids have been shown to complex bases and facilitate leaching of these elements.

Because SOC and pH exert a strong effect on other soil chemical properties, they can be used to estimate these properties using simple mathematical functions. These estimating functions are called continuous pedotransfer functions. In our study many soil properties were strongly related to SOC and/or pH. As expected, variation in SOC explained 98% of the total variation in total soil N (Table 2). Together with pH, SOC explained 82, 84, and 86 % of the variation in CEC, extractable Ca, and Mg, respectively. These results confirmed that the majority of negative charge for this soil came from organic matter and is pH dependent. Therefore, the increase in SOC and pH, as well as Ca and Mg present in the litter, provided an increase in Ca and Mg availability.

A great influence of SOC and pH on extractable micronutrients was also observed. Like Ca and Mg, B was strongly associated with SOC and pH, as was Mn (Table 2). In accord with other research, appreciable P accumulation (Mehlich I extractable) was observed with continued application of poultry litter, especially under conservation tillage. Stratification of extractable P in surface soil can increase the possibility of surface water contamination from runoff and erosion losses. However, increasing infiltration and soil coverage under conservation tillage might also diminish erosion and runoff and consequently decrease P contamination in surface water. This P increase as a result of litter application might also generate plant nutritional imbalances with micronutrients. However, our study showed that variations in extractable P were closely associated with extractable Zn and Cu. This should avoid possible imbalances among P and these nutrients. Likewise, a nutritional imbalance between Ca and B is unlikely as a linear relationship was observed between extractable Ca and B.

Our results confirm the importance of tillage, rotation, and source of N fertilizer as factors for changing soil properties. The majority of soil properties analyzed were affected by interaction effects of tillage and N source and some were also influenced by interactions with crop rotation. Phosphorus accumulation in the soil surface with litter under conservation tillage could increase risks of surface water contamination. Therefore, this needs more attention in future studies. Overall, the change in soil chemical properties provided by tillage, crop rotation, and litter were strongly related to SOC and pH. Thus, SOC and pH have an important role as basic soil quality indicators and are useful as continuous pedotransfer functions.

This paper was peer-reviewed and accepted. Since it was presented in the form of an interpretative summary, it was included here with other interpretative summaries.

Table 1. Soil organic C, pH, extractable Ca, and P from a long-term experiment with application of poultry litter under different tillage systems, averaged over rotations.

Depth	Conservation Tillage		Conservation Tillage		Conservation Tillage		Conservation Tillage	
	poultry litter	NH_4NO_3	poultry litter	NH_4NO_3	poultry litter	NH_4NO_3	poultry litter	NH_4NO_3
in.	C(%)				pH			
0 - 1.2	2.39 a†	2.07 b	11.6 a	11.1a	6.29 a	6.30 a	5.57 a	5.41 a
1.2 - 2.4	1.48 a	1.14 b	11.0 a	9.1b	5.91 a	5.57 b	5.99 a	6.00 a
2.4 - 4.8	0.95 a	0.95 a	9.2 a	7.5a	5.73 a	5.47 b	6.06 a	6.00 a
4.8 - 9.6	0.64 a	0.57 a	5.9 a	6.2a	5.82 a	5.58 a	6.00 a	5.90

Depth	Conservation Tillage		Conservation Tillage		Conservation Tillage		Conservation Tillage	
	poultry litter	NH_4NO_3	poultry litter	NH_4NO_3	poultry litter	NH_4NO_3	poultry litter	NH_4NO_3
in.	P(ppm)				Ca(ppm)			
0 - 1.2	154 a	51 b	61 a	31 b	1153 a	828 b	499 a	400 b
1.2 - 2.4	99 a	36 b	61 a	28 b	612 a	379 b	520 a	399 b
2.4 - 4.8	63 a	30 b	50 a	24 a	439 a	314 b	458 a	372 a
4.8 - 9.6	32 a	25 a	24 a	19 a	355 a	298 a	387 a	363 a

† Within a tillage and depth, N source means followed by the same letter in the row are not significantly different at the 0.05 level by LSD.

Table 2. Relationships among soil chemical properties from a long-term experiment with application of poultry litter under different tillage systems and rotations.

Dependent variable	Independent variable(s)	R^2
N	0.0019 + 0.036 C	0.97
CEC	- 7.78 + 2.02 C + 1.53 pH	0.82
Ca	- 1321.22 + 314.62 C + 251.09 pH	0.84
Mg	- 33.6 + 88.3 C + 61.4 pH	0.86
Mn	28.18 + 2.48 C - 4.64 pH + 3.17 CEC	0.72
Zn	- 1.43 + 3.44 C	0.55
B	-0.62 + 0.18 C + 0.12 pH	0.85
Zn	-0.73 + 0.061 P	0.80
Cu	0.004 + 0.019 P	0.69
B	0.045 + 0.00052 Ca	0.93

ON FARM COOPERATIVE RESEARCH AT THE CENTRAL SAVANNAH RIVER AREA CONSERVATION TILLAGE DEMONSTRATION FARM

Harry Schomberg[1], Richard McDaniel[2], Ken Wandless[3], Eddie Mallard[4], Tom Sanders
Dinku Endale, Alan Franzluebbers, and Ron Sharpe

AUTHORS: [1]USDA ARS, J. Phil Campbell, Sr., Natural Resources Conservation Center, 1420 Experiment Station Road, Watkinsville, GA, 30677; [2] Public Service Associate, University of Georgia, 715 West 6th Street, Statesboro, GA, 30830-0300; University of Georgia, Cooperative Extension Service, Burke County; Nutrasweet Kelco Company, Augusta, GA; [3]Monsanto, Waynesboro, GA; [4]Monsanto Crops Division, Statesboro, GA.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

The Central Savannah River Area Conservation Tillage Demonstration Farm (CSRA-CTDF) near Waynesboro, GA, was established in 1996 to develop and demonstrate sustainable cropping and tillage systems suitable for Coastal Plain soils. The project was undertaken as a joint effort of Monsanto's Crop Division, Monsanto's Nutrasweet Kelco Company and BioGro Inc. Board members selected from the three companies and members of the surrounding area agriculture community worked together to create a systematic farm plan to demonstrate the benefits of conservation tillage on Coastal Plain soils. Key members of this team are Richard McDaniel, the Burke County Extension Director, who serves as a production advisor, and Eddie Mallard who is the farm manager.

The farm has 640 acres of arable land comprised of 260 acres of row crops, 130 acres of Coastal bermudagrass hay, and 250 acres of Bahia grass and woodland. Two ponds were constructed in 1998 to provide water for two center pivot systems and a drip irrigation area. Major summer cropsinclude cotton, soybean, corn, and peanuts. Wheat and rye are grown during the winter as cover crops or cash crops. Proceeds from crop sales are used for farm improvements, 4H activities, and to fund a scholarship program targeted at Burke County farm children

Parts of the farm are used to demonstrate long-term effects of conventional and conservation tillage practices. Tillage comparisons are made on side-by-side 5 to 10 acre fields using standard farm machinery. Conservation tillage practices on these areas started in the spring of 1997. Prior to this time the whole farm had been managed under conventional tillage for more than 50 years.

Limited information is available on cropping and tillage system effects on indicators of soil quality for Coastal Plain soils. Multiple cropping and tillage systems at CSRA-CTDF provide a unique on-farm opportunity to evaluate changes in soil quality with contrasting management. Because practices implemented on certain fields are to remain in place and have recently begun we can monitor the expected changes and relate them to management, biomass inputs, and prior cropping practices. The long growing season in the Coastal Plain allows winter and summer cropping which increases the potential for biomass (organic matter) inputs. We expect the large biomass inputs will increase soil organic matter near the soil surface and improve soil physical, chemical and biological properties.

We are measuring soil quality changes under the following conditions:

- Conservation and conventional tillage continuous cropping following long term Bermuda grass sod.
- Conservation and conventional tillage peanut following corn.
- Conservation and conventional tillage cotton-rye.

Soil samples are collected during the winter and divided into 0 to 1, 1 to 3, 3 to 6, 6 to 12 and 12 to 24 inch (0 to 2.5, 2.5 to 7.5, 7.5 to 15, 15 to 30 and 30 to 60 cm) depths for physical, chemical, and biological analysis.

Chemical
CEC, pH, exchangeable acidity, NO_3, NH_4, total N and C, inorganic and organic P, K, Ca, and Mg.

Biological
Soil respiration (C mineralization), N mineralization, microbial biomass C and N

Physical
Soil texture and bulk density.

The first samples were collected in March of 1999 and will be analyzed this summer (preliminary results to be presented in the poster text).

ADDITIONAL FUTURE PLANNED STUDIES

1.) At the end of 5 and 10 yr of continuous conservation and conventional tillage comparison, we will measure infiltration and runoff using rainfall simulators.

2.) Evaluate N availability from commercial by-products, fertilizer, and poultry litter in conventional and conservation tillage systems.

3.) Determine effects on soil quality following conversion of highly erodible land from Bahia to continuous cropping.

IMPLICATIONS

We plan to use the results from this work to demonstrate how quickly changes in soil carbon and nutrient holding capacity occur for Coastal Plain soils following conversion of conventional tillage land to conservation tillage. Also effects of conventional and conservation tillage systems following conversion of grassland to crop land will be determined. By measuring soil quality changes under various cropping systems producers will be able to see how effective conservation tillage systems are in conserving soil C and increasing productivity. Because of the increased need for information on C storage the data will be helpful in quantifying tillage and cropping system effects on soil C sequestration in the Coastal Plain.

CRIMSON CLOVER-COTTON RELAY CROPPING WITH CONSERVATION TILLAGE SYSTEM

Sharad C. Phatak[1], Rick Reed[2], Wayne Fussell[3], W. Joe Lewis[4], and Glen H. Harris[5]

AUTHORS: [1]University of Georgia, P.O. Box 748, Tifton, GA 317943-0748; [2]University of Georgia, Cooperative Extension Service, Douglas, GA 31533; [3]Conway Vickers Road, Ambrose, GA 31512; [4]USDA-ARS, P.O. Box 748, Tifton., GA 31794; [5]University of Georgia, P.O. Box 1209, Tifton, GA 31794 Corresponding Author: S.C. Phatak, University of Georgia, P.O. Box 748, Tifton, GA 31793-0748 phatak@tifton.cpes.peachnet.edu
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTERPRETATIVE SUMMARY

Alternative production systems were evaluated at research and growers level due to environmental and economic concerns. In a conventional production system growers were dependent on high chemical and tillage inputs. Alternative systems like ‘Relay Cropping’ were based on use of cover crops, reduced tillage and reduced chemical inputs. Cotton became a crop of choice for evaluation of alternative production system after the success of Boll Weevil Eradication Program (BWEP) in early nineties in Georgia.

Research and grower field trials were conducted for seven years which included two years of research and five years of production in growers field. In research, trial crimson clover and subterranean clover “Relay Cropping Systems’ were compared with conventional system based on cotton production guides during 1991-1993. No fertilizers or insecticides were used in ‘Relay Cropping Systems.’ While recommended fertilizers and insecticides were applied. ‘Relay Cropping Systems” produced significantly higher yields than conventional systems during both years of research.

‘Relay Cropping Systems’ were evaluated in growers field plots in Coffee county. Crimson clover was planted in 1993, in 7.2 acres of non-irrigated land, which has re-seeded every year since. Cotton was planted from 1994 thru 1998. No insecticides were used during all five years of cotton production. Only starter solution and nitrogen fertilizers were used for four years from 1994-1997. In addition, sulfate of potash-magnesia was applied in 1998. This 7.2 acre field produced higher yields than the state average during all five years. Soil analyses indicate that clover has recycled nutrients and reduce leaching. ‘Relay Cropping Systems’ research trials and growers field trials reported provide answers to environmental and economic concerns raised by conventional cotton production systems. Further evaluation of these alternative systems for cotton production is warranted..

CONCLUSIONS

In ‘Relay Cropping Systems’ with legume cover crops and conservation tillage, cotton crops were grown with reduced fertilizer inputs and insecticide applications were not needed. Thus, these systems are economically feasible and environmentally friendly. More large scale adaptation is needed to understand weaknesses and strengths of these systems.

See full paper and its tables and figures in the Reviewed Papers Section of this Proceedings.

EVALUATION OF THE ADAPTATION OF ULTRA-SHORT SEASON CORN FOR THE MID-SOUTH

T.C. Keisling[1], H.J. Mascagni, Jr.[2], A.D. Cox[3], and E.C. Gordon[3]

AUTHORS: [1]Professor, University of Arkansas, Northeast Research and Extension Center, Keiser, AR; [2]Associate Professor, Louisiana State University, Northeast Research Center, St. Joseph, LA; [3]Research Specialists, University of Arkansas, Northeast Research and Extension Center, Keiser, AR.

REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTERPRETIVE SUMMARY

Research Question

Most soils in the Southern United States Are shallow with low water storage capacity. The majority of the rainfall occurs in the winter months, which means summer crops often are exposed to drought conditions. Planting alternative crops to avoid drought conditions has entailed the use of cereal crops and early maturing soybeans. The stored soil water and incidental rainfall are usually sufficient to meet the needs of these crops in the spring. Ultra-short season corn and grain sorghum cultivars have been developed for the northern corn belt, and these cultivars could also take advantage of the usually sufficient moisture if they matured about the time that wheat is harvested. The objectives of these experiments were to evaluate the potential of ultra-short season corn for the region and to observe its growth; characteristics and cultural practice needs.

Literature Summary

Even though the Southeastern United States receives in excess of 40 in. of rainfall annually, crops grown in the region can experience drought stress due to the timing of the rainfall and shallow soils that have low water storage capacity. Ultra-short season corn can avoid drought stress if it matures at the time that wheat is harvested. It would also return more plant residue to the soil than current dryland crops, such as cotton and soybeans, which could enhance the building of organic matter.

Study Description

Field experiments were conducted in Arkansas in 1998 and in Louisiana in 1994 and 1995. Observations were made in Arkansas on variety, plant population, N rates, soil compaction, drainage, and yield. In Louisiana, evaluations were made on variety, planting date, maturity, and yield. Corn was considered mature when 75% of the kernels in the middle portion of the ear had developed a black layer.

Applied Questions

Does ultra-short season corn have a niche in the South?

Potential evaportranspiration estimates for corn indicate that there would be sufficient moisture to meet the needs of ultra-short season corn in most years if it matured about the same time as wheat is harvested.

Are there any special cultural practices that need to be employed?

Soil compaction due to traffic patterns needs to be addressed. Land preparation, planting, fertilizer application, and pesticide application creates soil compaction which reflects in plant growth and survival. Drill planting does not provide adequate control of traffic patterns nor does it provide a necessary system of drainage. Planting in rows of at least 19 in. width with furrows for drainage is needed. Planting in 19 in. rows also permits the in-season N to be applied as a side dress application to avoid unnecessary fertilizer leaf burn.

Conclusions

There appears to be a niche in the South for ultra-short season corn. The development of suitable varieties could result in consistent desirable yields, and a chance to miss some weather related problems concerning quality, such as aflatoxin. An earlier harvest could mean better grain prices, and may present the possibility of double-cropping with soybeans. However, more research is needed regarding production systems in relation to these cultivars.

See this full paper and its tables, and figures in the Reviewed Papers Section of this Proceedings.

IRRIGATED MULTIPLE-CROPPING USING BROILER LITTER IN CONSERVATION TILLAGE

G. J. Gascho[1], B. H. Baldree[1], T. B. Brenneman[2], G. H. Harris[1], D. R. Sumner[2], R. K. Hubbard[3], A. W. Johnson[3], and W. W. Hanna[4]

AUTHORS: [1]Department Crop and Soil Science; [2]Department Plant Pathology, University of GA; [3] Nematodes, Weeds and Crop; [4] Forages and Turf, USDA-ARS, Tifton, GA. Corresponding author: G. J. Gascho, Department of Crop and Soil Science, University of GA./CPES, P.O. Box 748, Tifton, GA., email gascho@tifton.cpes.peachnet.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95, Athens, GA.

INTERPRETIVE SUMMARY

Research Question

Can an irrigated, multiple-cropping system including cotton, peanut, pearl millet for grain as summer crops and wheat and canola as winter crops be sustainable using conservation tillage and broiler litter applications? What commercial fertilization and how much additional fertility will be required for the various crops in the system? A 3-year and continuing experiment is being conducted in the Coastal Plain of Georgia to determine if double-cropped economical yields can be made in an irrigated double cropped system of main line and emerging crops.

Literature Summary

Recent work in the Coastal Plain indicates that peanut may be grown with strip-tilled subsoil tillage. Previously, all peanut farmers only used a conventional tillage system, involving several discings followed by deep moldboard plowing and seed bed shaping. There remains a tradition that peanuts will only produce in a deep, loose, and fluffy soil, but the recent research is debunking that myth. As progressive farmers move to conservation tillage with peanuts it promotes the system in all crops, since peanut was the main reason that conventional tillage is dominant in the peanut belt of the Coastal Plain. Other crops have previously shown to be profitably grown using conservation tillage. With conservation tillage will come the benefits of less soil erosion by water, a major conservation problem in the area.

Georgia is now the number one broiler litter state in the nation. Most of the current expansion is in the Coastal Plain. One important reason for the expansion in south Georgia is that the Coastal Plain has abundant crop land for disposal and utilization of the litter. It is apparent that applications of broiler litter will be made on land to be planted to peanuts and cotton, the main cash crops in the Coastal Plain. Little is known on the reactions of these crops to unincorporated broiler litter application in the Coastal Plain using conservation tillage.

Study Description

An experiment was initiated on the Coastal Plain Experiment Station, Tifton, GA on a Tifton loamy sand, (Plinthic Kandiudult) in Feb. 1996. The experiment is a 3-year irrigated double-cropped rotation with each crop grown each year. The sequence of crops in a single cycle (three cycles) are cotton, fallow, peanut, canola, pearl millet, and wheat. Within the cycles there are four broiler litter rates of 0, 2, 4, and 6 ton/acre as the main plots of a split-plot arrangement of a randomized complete block design. Within each litter rate, six fertilizer treatments are included to attempt to balance plant nutrition for top yield, grade, and profitability. The moldboard plow was not used in this experiment and surface tillage has been eliminated gradually in the 3 years of the experiment reported. Soil samples were obtained in main plots in depth increments of 0-6 , 6-12 , 12-18, 18-24, and 24-30 inches each winter to evaluate changes in nutrient elements with soil depth as affected by litter rate. Responses to broiler litter to applications and to supplemental fertilization for each crop and litter rate were determined.

Applied Questions

What have been the main effects of the shift to more conservation tillage with application of broiler litter in this experiment?

Mehlich-1soil test P levels are increasing rapidly in the surface soil where more than 2 ton broiler litter/acre has been applied. Cotton yields in our experiment were 2 to 2.5 greater than the state average in all 3 years of the experiment. The main reason for the high yields was irrigation, but broiler litter alsohad a large positive effect on yield. The effect was positive to the 4 ton rate in 1996 and 1997 and then only to the 2 ton rate in 1998. The different response in 1998 was possibly due to the fact that N and P were increasing to excessive levels in the soil due to repeated applications of broiler litter. Following application of litter to the 1998 cotton, a total of 20 tons had been applied at the 4 ton rate and 30 tons at the 6 ton rate. In all 3 years, peanut value/acre was reduced greatly by application of broiler litter, regardless of the rate. Wheat yield was poor in 1997 (due to late detected disease problems) and good in 1998. Wheat responded well to broiler litter . Response to litter was to the 4 and 6 ton rates for the 2 years completed. Canola yields above state averages were produced on the plots in 1997 and 1998. Yields responded positively to litter application, peaking at the 4 ton and 6 ton rates for 1997 and 1998, respectively.

What crop responses were made by applications of inorganic fertilizers following broiler litter application?

Over all litter rates, cotton yields were increased by starter fertilizer applications in 1996 and 1997, but not in 1998. Three foliar applications of KNO_3 did not produce significantly more cotton yield. That result may have been different if soil test K were at a "low" rather than at a "medium" level. Following application of 2 ton/acre litter gross economic increases were not consistent over the 3 years of cotton in the rotation. Mean increases of 66 and $33/acre/year were attained from 10-34-0 and 12-22-5 (2S) starters, respectively. Peanut did not respond to starter fertilizers. Over all litter rates in wheat, top dress dribble application of 40 to 60 lb N as UAN on about 15 February (early) produced the greatest yield.. There appeared to bea penalty for late application (15 March) and no additional response to two applications. At the 2 ton litter rate, approximately $60/acre gross revenue was averaged by early applications of 40 to 60 lb N. Responses to top dress dribble UAN were also significant for canola, but different than for wheat. Application of the UAN 90 DAP resulted in greater response than application at 45 DAP. However, application on wheat at 45 DAP and on canola at 90 DAP arrived at nearly the same calender date, possibly suggesting that specific weather conditions may have been important in the observed responses. At a 2-ton litter rate, our data suggest profitable responses to dribble applications on canola. The gross responses averaged $63/acre/year for a single application of 40 lb N at 90 DAP and $84/acre/year when two applications of 40 lb N were made.

Recommendations

Broiler litter application should be limited to no more than 2 ton/acre/crop in a double-cropped conservation-tilled system. Greater rates of application appear to be increasing P levels in the surface soil. The excessive P will likely be subject to losses in surface runoff. Broiler litter application prior to planting peanut should be avoided. Accurate and precise methods for prediction of fertilizer needs for crop production following broiler litter application need further development.

See this full paper and its tables and figures in the Reviewed Papers Section of this Proceedings.

FARMING AND WILDLIFE IN THE SOUTHEAST

John P. Carroll, Ph.D.

AUTHOR: Daniel B. Warnell School of Forest Resources University of Georgia Athens, GA 30602
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95, Athens, GA.

Abstract. The settlement and clearing of forests in the Southeastern United States resulted in marked changes in the composition and populations of our native wildlife. Some early successional species like the northern bobwhite quail flourished during much of the 19th and 20th centuries as a by-product of agriculture. Diverse farming with rather low levels of chemical inputs and presence of large amounts of untilled land combined to provide excellent habitat. In the latter portion of the 20th century several trends are evident and are correlated to the decline of many of our early successional wildlife species. This period has seen a decline of farm acreage with widespread reversion to forested habitats and/or urbanization. However, the distribution of these losses of farmland has not been even with some regions seeing very little land use changes whereas others have lost almost all farmland. This trend probably represents simple loss of habitat for early successional species. In addition to losses of habitat we have also seen both intensification, and specialization on remaining farmland. Intensification and specialization represent changes that often negatively impact wildlife living in farmland ecosystems. There appears to be little opportunity for increasing land area devoted to production agriculture in the Southeast, therefore, in order to reverse the wildlife declines that have occurred over the past 50 years, we need to concentrate on improving the quality of remaining farmland for wildlife. We are just beginning to see the implementation of agricultural practices in the Southeast that might help to mitigate impacts of modern production agriculture. We have to enter a new phase of farmland wildlife management where wildlife is no longer just an accidental by-product of farming, but an integral part of our agricultural ecosystem.

BENEFITS OF NO-TILL SOYBEAN PRODUCTION TO BOBWHITE QUAIL

William E. Palmer[1] and Walter M. Lane[2]

AUTHORS: [1]Tall Timbers Research Station, 13093 Henry Beadle Dr., Tallahassee, FL 32312; [2]Department of Zoology, North Carolina State University, Raleigh, NC 27695.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*, Tifton, GA. 6-8 July 1999. Georiga Agriculture Experiment Station Special Publication 95, Athens, GA.

Northern bobwhite populations have decline dramatically in the Southeast. Population declines are likely caused by habitat loss related to intensified land use since the 1970's. Between 1992 and 1998, data from replicated, on-farm research clearly shows habitat loss explains observed declines. Specifically, a paucity of nesting and brood-rearing areas was identified as limiting quail populations on agricultural landscapes. Of special interest were data showing quail used no-till crop fields in preference to conventional tilled fields. Female quail and quail chicks require high diets high in protein and energy for reproduction and growth, respectively. We hypothesized that quail chicks were more likely to meet daily nutritional needs foraging in no-till crop fields than tilled crop fields. Our research found that human-imprinted chicks fed at significantly higher rates in no-till corn and soybean fields. Feeding rates of chicks in fields of soybeans drilled into wheat stubble were such that chicks were capable of meeting daily nutritional needs in < 6 hours of foraging as compared to > 20 hours in tilled soybean fields. In paired-plot comparisons, quail chicks gained significantly more body weight in no-till soybeans than till-planted soybeans. Our results determined that at least in some years, no-till soybeans drilled into wheat stubble provide excellent brood habitat for quail. Our results suggest that no-till practices may be an important component of sustaining quail populations on agricultural landscapes in the South.

TRANSGENIC CROPS AND WILDLIFE

John R. Anderson Jr.

AUTHORS: Monsanto Company. Email: JOHN.R.ANDERSON@monsanto.com.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95, Athens, GA.

Biotechnology is revolutionizing agriculture. Since transgenic crops offer control of weed and insect pests with unprecedented simplicity and economic benefits, growers have rapidly adopted these technologies. Easily overlooked is the fact that transgenic crops can generate significant environmental benefits that translate into improved wildlife habitat. In addition to reducing insecticide use, the products of biotechnology are catalyzing grower adoption of no-tillage crop production systems that improve water quality as they reduce soil erosion and fossil fuel usage. No-tillage systems positively influence habitat quality for wildlife species like the bobwhite quail. The tandem of transgenic crops and no-tillage production methods form the foundation of a new vision for agricultural landscapes. In that vision, profitable, innovative cropping systems (ultra-narrow row cotton, for example) are managed alongside filter strips, field borders and riparian areas in agricultural enterprises that are both profitable and beneficial to wildlife.

TRANSITION ZONE MANAGEMENT: FITTING WILDLIFE IN TO MODERN FARMING

John P. Carroll, Ph.D.

AUTHOR: Daniel B. Warnell School of Forest Resources University of Georgia, Athens, GA 30602.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*. Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. Modern agriculture still provides the opportunity to manage for wildlife both in and out of the crop. Transition zones are defined as those areas between crop fields and other crop fields, other land uses, and/or non-crop habitats, such as streams or woodland. In the Southeast most transition zone management has been directed toward control of non-point source water pollution. However, wildlife benefits of this management have received much less attention. Transition zone management techniques such as herbaceous field margins, hedgerows, conservation headlands, and center-pivot irrigation corners, and beetle banks offer opportunities to increase early successional wildlife without sacrificing farm income. Although some of these techniques have enjoyed great success for integrating wildlife conservation and farming in other regions, most of the techniques have not been tested in the Southeast. Generally, these types of management attempt to create either more permanent vegetation through the year or address various limiting factors in the life history characteristics of target wildlife species. For example, in North Carolina, herbaceous field borders along drainage ditches have been used successfully to improve quail habitat and run-off water quality. In the United Kingdom, conservation headlands have been used to double brood survival rates of gray partridge, one of their most important gamebirds. Not only do these technique not have to have a major impact on farm production, but they can provide added wildlife, aesthetic, and water quality values. The key here is that the most useful of these techniques have come when wildlife and agricultural interests have worked together to develop management that is beneficial to both wildlife and farming.

WHAT ARE GEORGIA HUNTING LEASES WORTH TODAY?

Jeff Jackson, Ph.D.

AUTHOR: Daniel B. Warnell School of Forest Resources University of Georgia Athens, GA 30602
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA, 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication. 95 Athens, GA.

Just like the price of land, hunting leases vary greatly according to a wide array of variables. A number of the important factors include proximity of the land to large cities, the types of game species that are available to hunt, and the populations of those game species. In addition, aesthetics of the property, other kinds of amenities, and the types of advertising done by the landowner to find customers have great impact on hunting lease prices. Price ranges for hunting leases in the state of Georgia are discussed.

MANAGING PRIVATE LANDS FOR WILDLIFE

Reggie Thackston[1] and Mark Whitney[2]

AUTHOR: [1]Senior Wildlife Biologist and [2]Biologist, Georgia Department of Natural Resources, Wildlife Resources Division 116 Rum Creek Drive, Forsyth, GA 31029

REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*, Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

In Georgia, and across the Southeast, the future welfare of wildlife rests primarily in the hands of private landowners. Why? Because habitat (i.e. food, cover, water, and space) is the key to wildlife abundance and over 93% of Georgia and 75% of the Southeast is in private ownership. Most landowners have a variety of objectives for their land and blending the management of multiple natural resources is not an easy task. Often the primary uses are timber, crop and/or live stock production, with wildlife being a secondary objective. The first steps to successful integration of management practices should include setting realistic objectives, inventorying current habitat conditions and capabilities, and developing long-range plans. The good news is there are many sources of help for landowners desiring to enhance wildlife habitat on their lands. State fish and wildlife agencies have professionally trained wildlife biologists located throughout each state who are available to work with landowners, free of charge, in the development of wildlife management plans. Other agencies including the Natural Resources Conservation Service, University Cooperative Extension Service, and state forestry agencies are also available to provide landowners with technical assistance in various aspects of natural resource management. In addition there are private consultants that can be contracted for assistance. When wildlife is one of the land management objectives, landowners should be certain that persons assisting with the planning are professionally trained in wildlife management. Furthermore, when multiple resources are involved, as is often the case, an interdisciplinary team approach usually provides the best results. In addition to technical assistance landowners may qualify for economic incentives for wildlife habitat development. For example, there are federal programs that may provide cost share and in some cases incentive payments for certain habitat practices. The most notable are those of the 1996 Farm Bill. Some state wildlife agencies also have cost share programs that address wildlife management on private lands and there are private organizations that provide seed and seedlings and in some cases financial incentives for wildlife habitat improvement. Landowners seeking assistance with wildlife management can start by contacting the local office of their state fish and wildlife agency.

The Effect of Habitat Manipulation on Insect Diversity and Bobwhite Quail Populations in a Cotton Production System

Randy D. Hudson

AUTHOR: Entomologist, College of Agricultural and Environmental Science, The University of Georgia, PO Box 1209 Rural Development Center Tifton, GA 31793.

REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conse rvation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Bobwhite quail populations in Georgia have decreased dramatically in the last 40 years. Farms where over 100 documented coveys resided in the early 1960's now have less than 10 today. The southern coastal plain is composed of rolling land of mixed woods and small fields providing excellent habitat for quail development. But in some cases, even under conditions of excellent habitat quail populations continued to decline. Only recently have researchers identified the necessary link between suitable habitat and food availability, especially insects. Insects compose a very high percentage of the daily diet of newly hatched quail chicks. Absence of insects even in the most suitable of habitat all but ensures an environment for a population decline. It is the combination of cover from predators, the availability of an insect-rich source for chicks, and a sustainable range of fauna that may hold the answer to quail reestablishment. No other system is less suitable for quail than one with intensive cotton production. Cotton traditionally requires multiple insecticide applications. Often these insecticide applications are detrimental to the birds, and reduce the availability of insects for foraging chicks. Wolf Creek Farm is an diversified farming operation located in Turner County, Georgia. The farm is comprised of 2200 acres of cotton, peanut, corn and timberland. The farm was known to contain over 100 coveys of quail in 1960. In 1998, the first year of the project, only 6 coveys could be found on the farm. The Wolf Creek Project is an attempt to reestablish quail in an intensive farming system containing cotton. The project involves manipulation of field boarders, planting of food plots, selection of alternative farming practices(conservation tillage), use of insect resistant cotton varieties (Bt. cotton), selective use o f soil insecticides and herbicides for pest control, weed refugia for food and protection, controlled burning, fire ant control and predator elimination. In the last two years over 80 plots have been planted for quail establishment on Wolf Creek. Insect populations are also being compared between each of the different plots and correlated to quail success.

EFFECTS OF CLOVER STRIPCOVER CROPPING OF COTTON ON SONGBIRDS POPULATIONS AND NORTHERN BOBWHITE BROOD HABITAT

Sandy B. Cederbaum[1], Elena B. Goldberg[1], Robert J. Cooper[1], and John P. Carroll[1]

AUTHORS: [1]Daniel B. Warnell School of Forest Resources University of Georgia Athens, GA 30602
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. Changes in agriculture in the state of Georgia and the Southeast have had a tremendous effect on populations of northern bobwhite quail (*Colinus virginianus*) and many early successional songbirds. The change from rather diverse small farms to large operations, generally geared to production of a few crops, has generally had a negative impact on farm wildlife. Heavy pesticide use to battle key agricultural pests has had a carryover effect by removing neutral and beneficial insects required by many breeding birds. Cotton, which requires more technological inputs than many row crops, has therefore traditionally been viewed as detrimental to wildlife. The use of clover strip-cropping has been shown to revitalize beneficial insect communities in cotton fields. This diverse community reduces the need for traditional pest control while also avoiding unnecessary or costly inputs that many alternative techniques currently require. The inherent structure of cotton rows along with the boost in insect diversity with strip- cropping suggests a possible positive agriculture/wildlife interface. We are studying the effects of strip-cropping cotton and clover versus conservation tillage and conventional cotton on the density and success of passerine nests, as well as the suitability of brood habitat for the northern bobwhite. Variations in vegetation and arthropod communities throughout the breeding season are being measured. In addition, avian species composition and usage will be monitored during the migration and winter.

PART 2

Peer-Reviewed Papers

CONSERVATION TILLAGE IN IRRIGATED COASTAL PLAIN DOUBLE-CROP ROTATIONS

C. C. Dowler[1], J. E. Hook[2], S. H. Baker[3], G. J. Gascho[4], A. W. Johnson[5]

AUTHORS: [1]Research Agronomist (retired) and [5]Supervisory Research Plant Pathologist, USDA-ARS Nematodes, Weeds and Crops Research Unit, P.O. Box 748, Tifton, GA 31793-0748; [2,4]Professor and [3]Asst. Research Scientist (Emeritus), Crop and Soil Sciences Department, University of Georgia, P.O. Box 748, Tifton, GA 31794-0748. Corresponding Author C. C. Dowler; Email: dowler@tifton.cpes.peachnet.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication. 95. Athens, GA.

Abstract. We conducted three tillage experiments involving small grain grown for grain and double-cropped with cotton, soybean, or peanut under irrigation. The soils were Tifton or Pelham loamy sand. The experiments utilized irrigation application technology and integrated pest management practices. Our objective was to compare strip-till, no-till, ridge plant or subsoil without seedbed preparation to moldboard tillage and to study the effects of these tillage practices on crop production. Each experiment was initiated by moldboard tillage and seeding small grain. The various tillages were established after harvesting the first small grain crop and continued for the duration of the experiments. In subsequent years, the small grain crop was seeded into the preceding crop residue. One experiment was maintained for 11 years with strip tillage for the summer row crop. The other experiments were conducted for 4 or 5 years and compared strip tillage, no-till, ridge plant, and subsoil without seedbed preparation to moldboard tillage. The initial moldboard tillage always resulted in the highest small grain yield. Crop production varied from year to year, but in general cotton, peanut, and soybean yield were similar for strip and moldboard tillage. No-till generally resulted in lower yields. No insecticides were applied on any crop after 1991. No unusual disease problems occurred, although Cylindrocladium blackrot (CBR) developed on strip-till peanuts in 1996 and 1997. Weed management relied heavily on post-emergence herbicide treatments. Yellow nutsedge was a much greater problem in moldboard than in any conservation tillage. Significant shifts in weed populations did not occur, although morningglory species appeared to be increasing in peanuts. Soil pH, Ca, and Mg in the profile were decreased when cotton was included in the rotation.

INTRODUCTION

In present day crop production, attention to reduce soil erosion, crop production inputs, and adverse environmental impact, and yet maintain productivity, has recently focused on conservation tillage technology. There are extensive literature citations on individual characteristics and aspects that influence the adoption and management of conservation tillage. Most of the reduced tillage database originated from research in the midwest. Although their review emphasized herbicide soil interactions, Locke and Bryson (1995), reviewed many of the factors and characteristics involved in conservation tillage, such as organic matter, physical characteristics, pH, moisture, and nutrients. Conservation tillage research to date has produced variable results in terms of potential crop yield and other factors, such as erratic weed management (Doub et al., 1988; Elmore and Moorman, 1988; Forcella and Lindstrom, 1988; Patterson et al., 1989; Reddy et al., 1995). While some research has been conducted on coastal plain soils, additional research is needed to identify and characterize management problems and ecological shifts in coastal plain soils (Brecke and Shilling, 1996; Clemens et al., 1996; Patterson et al., 1995). Crops grown with conservation tillage under irrigation may present very rapid ecological and plant community changes. Research on conservation tillage under sprinkler irrigation has been very limited (Keeling et al., 1995). The interaction on conservation tillage and irrigation within multiple cropping sequences has not been studied in detail under coastal plain conditions. The results reported herein, are specifically designed to evaluate that area.

The objective of this research was to establish and evaluate the success of reduced tillage cropping systems to crop rotations common in the southeastern coastal plain that utilized irrigation application technology and integrated pest management techniques.

MATERIALS AND METHODS

Field studies were conducted at three locations at or near the University of Georgia, Coastal Plain Experiment Station, Tifton, GA.

In December 1986, two rotation experiments were established on Tifton loamy sand. One identified hereafter as IPM Conservation Tillage Rotation was initiated on plots previously used for various integrated pest management multiple rotation studies. The rotation was initiated in December 1986 by moldboard plowing and planting triticale. The only subsequent tillage for the duration of the experiment (through 1997) was strip-till (in row subsoiling with row preparation) on the summer crop, and inverting peanuts at harvest. Three cropping sequences were established and listed in Table 1. The second experiment hereafter identified as RDC was established in 1986 by moldboard plowing the experimental area, establishing the ridge plant tillage, and planting triticale. After the triticale harvest in 1987, strip-till, no-till, and moldboard plow tillages were established in addition to the ridge plant tillage. In 1988, an adjacent plot planted to rye became available so we established a moldboard plow tillage after burning small grain residue, strip-till after burning small grain residue, strip-till and no-till practices and rotated the two areas between small grain, soybean, and cotton (Table 2). The RDC study was conducted through 1991.

In 1993, a wheat-peanut-cotton rotation was established on Tifton and Pelham loamy sand soils, hereafter identified as the ABAC and Bowen studies, respectively. The experimental areas were moldboard plowed and planted to wheat. Following the small grain harvest in the summer of 1994, both cotton-peanut and peanut-cotton rotations were established in the tillage practices of moldboard plow, strip-till, no-till, and subsoil without seedbed preparation and continued for 4 years (Table 3).

All tillage plots were 18 ft. wide and the row crops (peanut, cotton, soybean) were planted in 36" rows. Commercially available equipment was used in all experiments, except that a 6 ft. wide plot drill was modified to plant small grains in crop residue. All rotations were initiated under sprinkler irrigation. All experiments included a double-crop rotation; winter grain grown for grain and a summer crop of cotton, peanut, or soybean following the small grain. The small grain stubble was left at combine height for all tillages except for moldboard plow which was flail mowed and/or burned and disc before plowing. The crop varieties utilized were generally early maturing varieties recommended by the University of Georgia Extension Service and were seeded at recommended rates. Fertilizer programs were based on soil sampling and codebook recommendations established by the University of Georgia Extension Service. Fertilizer was applied through irrigation as were all other agrichemicals (herbicides, insecticides, and fungicides) whenever feasible. All pest management practices were based on scouting. After each tillage treatment was established they remained on the same plots for the duration of the experiment. In all experiments the small grain was drilled into the preceding crop residue without any tillage except for inverting peanuts.

A split plot in strips experimental design with six replications was used in the IPM rotation. A randomized complete block design with four replications was used in the other experiments. Data were collected from a 6 ft. wide, 25 ft. long strip in each tillage plot included crop stand, yield, weed population estimates, disease incidence, surface residues, and soil fertility analysis. Yield data were analyzed by ANOVA at the 0.05 probability level of significance.

In December 1997, soil samples were collected from the center plot of the IPM conservation tillage study to a depth of 16". The sampling sites were taken between the strip-till areas that had remained undisturbed since December 1986, except for peanut digging. These samples were analyzed for soil pH, phosphorus, potassium, calcium, and magnesium.

RESULTS

IPM Conservation Tillage Study

The crop yield summary of this study is shown in Table 4. In 1992, wheat was substituted for triticale and peanut was substituted for soybean. The 1987 triticale was drilled into a moldboard plowed seedbed, which resulted in excellent yield. In the subsequent years, the small grain was drilled into the preceding crop residue, which resulted in reduced small grain yield for the duration of the experiment. Cotton yield reflected year to year variation, but rotation did not affect cotton yield. The same was generally true for soybean and peanut. In 1994, rainfall in excess of 30" occurred on both peanut and cotton. Although other management practices were maintained, the growth of both crops was restricted and reflected in severe yield reduction. There was some year to year variation, but rotation had little effect on peanut or soybean production, except for peanut in 1996. This is partly the result of an increased incidence of Cylindrocladium black rot in rotation 2. Although Cylindrocladium was present in both rotations, it was much more severe in rotation 2, which also caused excessive pod loss at harvesting. The disease was also present in 1997 in rotation 2 peanut but not nearly as severe as in the previous year.

In December 1997, the undisturbed soil profile was sampled to a depth of 16" and analyzed for pH (water), and Mehlich-1 extractable, phosphorus, potassium, calcium, and magnesium. The results are shown in Tables 5, 6, and 7 and Figure 1. It is quite evident that a continuous conservation tillage rotation involving cotton decreased soil pH, Ca and Mg more than rotation with peanut or soybean. This was specifically true for the soil profile from 3 to 9".

RDC Conservation Tillage Study

The yield results of the RDC Conservation Tillage Rotations 1 and 2 are shown in Tables 8 and 9. Moldboard plow tillage consistently resulted in high triticale yield as compared to the other conservation tillages.

In general, tillage practices did not significantly affect cotton production, except for Rotation 1 moldboard burn in 1988 and no-till in Rotation 2 in 1989. Moldboard tillage resulted in consistently high yield.

Tillage practices did not influence soybean production except for ridge plant in Rotation 2. However, moldboard tillage consistently resulted in high yield over all years.

ABAC and Bowen Wheat-Peanut-Wheat-Cotton Rotation

The results from the ABAC and Bowen rotations from 1994 through 1997 are shown in Tables 10-13. Chemigate means that all production materials were applied through irrigation if feasible. Conventional means that all production materials except fertilizer were applied by ground application. All fertilizer to all crops was applied through irrigation.

Although there was some variation within year and also variation between years, chemigation and conventional application did not affect the yield of any crop at either location.

In most instances, tillage did not affect wheat yield at ABAC. In 1994, the cotton yield was extremely low. The greatest yield reduction occurred in the moldboard plow. At least in part, this yield reduction was the result of heavy rains that occurred after cotton planting which eroded plots and caused the soil to crust over which reduced cotton stands. From 1995 to 1997, peanut and cotton yields at the ABAC location were generally similar in the moldboard and strip-tillage and least in the no-till (Tables 10 and 11). The subsoil-till treatment yields were generally intermediate and somewhat inconsistent. However, in 1997, the highest peanut yield was in no-till tillage and lowest was in moldboard plow.

In the Bowen wheat-peanut-wheat-cotton rotation, moldboard plow generally resulted in the highest wheat, cotton, and peanut yields, but strip-till was similar in several instances. (Table 12). No-till resulted in the lowest cotton and peanut yield. This was also true in the Bowen wheat-cotton-wheat-peanut rotation (Table 13). However, peanut yield was lower in the moldboard tillage than in strip-till, subsoil-till, and no-till in 1995 and 1997. This may have been the result of sampling error because two replications of the moldboard tillage plots were extremely low.

DISCUSSION

There are many approaches that can be taken to utilizing conservation tillage in crop production systems of the southeastern coastal plain. The approach reported herein certainly cannot be adapted to all situations, but it does point out some factors that must be considered.

A primary factor in the utilization of successful conservation tillage is soil moisture. In the early 1970's, some limited studies were conducted on evaluating herbicides in no-till situations. Three out of four years were complete failures for a lack of soil moisture. Irrigation has not been promoted as a part of conservation tillage production, but it must be considered. All of the crops grown in these experiments were irrigated at least one time and as many as eleven times in certain situations. On several occasions, irrigation was utilized to establish crop stand. Soil moisture is also important at or soon after crop planting to activate soil applied herbicides. On the other hand, excessive soil moisture can be detrimental. In 1994, excessive rainfall soon after planting resulted in erosion and surfacing crusting of the soil, specifically in moldboard and strip-till tillages.

Timeliness of planting and establishing a good summer crop stand are extremely important for managing the crop during the growing season and obtaining consistent high yields. In our studies, planting small grain in early December and harvesting in mid to late May were consistent. However, for various reasons, we sometimes had to plant peanut or cotton as late as mid June. One to two week delay in planting has a significant affect on crop maturity in October or early November.

The interaction of cropping with soil depth for soil pH, Ca, and Mg indicates lower values when cotton was in the system. This is no doubt a result of increased application of ammoniacal nitrogen in the cotton crops, while no nitrogen was applied for the leguminous soybean or peanut crops (Fig. 1).

Insect management was not a major factor in these experiments. Insect application requirements for the boll weevil eradication program on cotton were followed through 1990. After 1991, no additional insecticide applications were made on cotton. The other crops required no insecticide applications during the duration of the experiments. There was no consistent monitoring of soil insects, but it did appear that the incidence of wire worm and southern corn root worm were increasing on peanuts on the IPM conservation rotations in 1996 and 1997. Observations would suggest that careful attention be paid to soil insect populations.

Weed control data were not presented, although some weeds were generally present at harvest for all crops. Scouting and reliance on post-emergence weed management programs were generally effective. Yellow nutsedge was a persistent problem, particularly in the moldboard plow peanut rotations. Yellow nutsedge was not a major problem in the reduced tillage rotations. Florida beggarweed and some morningglory species emerged later in the growing season and were present at peanut harvest. Most of the weeds present emerged in the crop row middles and were not competitive with the crop. The rotation sequence and weed management programs did not result in a major weed population shift. Weeds that were present in the initiation of experiments were generally the same weeds that were present when the experiments were terminated. It did appear that some morningglory species may have been increasing in the peanut rotations.

The results of these experiments indicate several items to be considered. Equipment utilized in conservation tillage, especially in planting, has improved greatly over the past several years. However, the precision needed to control planting depth still needs to be improved. The crop seed needs to be placed in good contact with the soil at the proper depth to obtain a uniform stand. Soil moisture at planting is also a critical factor. Irrigation can provide some consistency in soil moisture. The full implication of maintaining adequate fertility levels in conservation tillage is not fully understood. Our results would indicate we are not fully utilizing the fertilizers applied. Our results would also indicate we are not effectively managing the soil moisture through the growing season. The insect management program in these experiments were minimal. More extensive monitoring of soil insects would be desirable. Weeds are still a major factor in conservation tillage production systems. Weed management in these experiments were acceptable and did not appear to produce any major ecological shifts. This was based partially on crop rotation and also on rotation of herbicides. There is also some limitation for weed management in double-cropping conservation tillage systems because of potential herbicide carryover from one crop the a next. This may restrict use of some effective and economical herbicides. All of these experiments were initiated by moldboard plowing and planting small grain. This initial tillage always resulted in our best small grain production. It would appear that some tillage for producing small grains may be desirable if yield is important.

An extensive economic analysis of these experiments has not been conducted. If equipment is available, timeliness of planting, especially in conservation tillage, and harvesting were feasible in our rotation systems. However, it would appear that more consistent high crop yields are necessary to make conservation tillage economically feasible.

Agricultural technology has changed tremendously since these experiments were initiated. Recent advancements in biotechnology, new pest management chemistry, and new varieties require that research be continued in conservation tillage cropping systems.

ACKNOWLEDGMENTS

This research was a multi-disciplinary team approach involving many people. However, the authors would like to acknowledge the technical support of T. E. Sklany, J. E. Davis, and D. E. Scott for coordinating and conducting day to day activities on these experiments, and to Ben G. Mullinix, Jr., Agricultural Research Statistician, for developing the statistical analysis of these data.

LITERATURE CITED

Brecke, B. J. and D. G. Shilling. 1996. Effect of crop species, tillage, and rye (Secale cereale) mulch on sicklepod (Senna obtusifolia). Weed Science 44:133-136.

Clemens, D. R., D. L. Benoit, S. D. Murphy, and C. J. Swanton. 1996. Tillage effects on weed seed return and seed bank composition. Weed Science 44:314-322.

Doub, J. P., H. P. Wilson, T. E. Hines, and K. K.Hatzios. 1988. Consecutive annual applications of Malachlor and metolachlor to continuous no-till corn (Zea mays). Weed Science 36:340-344.

Elmore, C. D. and T. B. Moorman. 1988. Tillage related changes in weed species and other soil properties. Proc. SWSS 41:290.

Forcella, F. and M. J. Lindstrom. 1988. Weed seed populations in ridge and conventional tillage. Weed Science 36:500-503.

Keeling, W., W. M. Lyle, A. B. Onken, K. Hake, J. F. Farris, and J. G. Smith. 1995. Evaluation of irrigated and dry land cropping systems for the Texas southern high plains. Arkansas Agricultural Experiment Station Special Report 169 pg. 109-112.

Locke, M. A. and C. T. Bryson. 1997. Herbicide-soil interactions in reduced tillage and plant residue management systems. Weed Science 45:307-320.

Patterson, M. G., C. Burmester, and C. D. Monks. 1995. Weed control research with conservation tillage cotton in Alabama. Arkansas Agricultural ExperimentStation Special Report 169 pg. 21-24.

Patterson, M. G., L. Wells, and G. R. Wehtje. 1989. Weed control in reduced and conventional tillage cotton rotations. Proc. SWSS 42:301.

Reddy, K. N., R. M. Zablotowicz, and M. A. Locke. 1995. Chlorimuron sorption and desorption in soils from two tillage systems. Proc. SWSS 48:265-266.

Wickes, G. A., D. E. Smika, and D. W. Hergert. 1988. Long-term effects of no tillage in a winter wheat (Triticum aestivum)-sorghum (Sorghum bicolor)-fallow rotation. Weed Science 36:384-393.

Table 1. Crop Rotations in IPM Conservation Tillage Study.

Year	Crop rotation 1	Crop rotation 2	Crop rotation 3
1987	triticale-cotton	triticale-soybean	triticale-cotton

1988	triticale-cotton	triticale-soybean	triticale-soybean
1989	triticale-cotton	triticale-soybean	triticale-cotton
1990	triticale-cotton	triticale-soybean	triticale-soybean
1991	triticale-cotton	triticale-soybean	triticale-cotton
1992	wheat-cotton	wheat-peanut	wheat-peanut
1993	wheat-cotton	wheat-peanut	wheat-cotton
1994	wheat-cotton	wheat-peanut	wheat-peanut
1995	wheat-cotton	wheat-peanut	wheat-cotton
1996	wheat-cotton	wheat-peanut	wheat-peanut
1997	wheat-cotton	wheat-peanut	wheat-cotton

Table 2. Crop Rotations in RDC Conservation Tillage Study.

Year	Rotation 1	Rotation 2
1987	-------	triticale-cotton
1988	rye-cotton	triticale-soybean
1989	triticale-soybean	triticale-cotton
1990	triticale-cotton	triticale-soybean
1991	triticale-soybean	triticale-cotton

Table 3. Crop Rotation in ABAC and Bowen Conservation Tillage Study.

Year	Rotation 1	Rotation 2
1994	wheat-peanut	wheat-cotton
1995	wheat-cotton	wheat-peanut
1996	wheat-peanut	wheat-cotton
1997	wheat-cotton	wheat-peanut

Table 4. Crop Yield Summary for Ipm Conservation Tillage Study.

Year	Crop rotation 1		Crop rotation 2		Crop rotation 3		
	triticale Bu/A	cotton lint lb/A	triticale Bu/A	soybean Bu/A	triticale Bu/A	cotton lint lb/A	soybean Bu/A
1987	56	854	50	26	72	712	--
1988	35	799	45	29	43	--	31
1989	30	666	30	29	29	715	--
1990	33	741	43	25	30	--	25
1991	21	360	17	31	14	551	--
	wheat Bu/A	cotton lint lb/A	wheat Bu/A	peanut lb/A	wheat Bu/A	cotton lint lb/A	peanut lb/A
1992	30	470	42	2867	33	--	2649
1993	18	578	24	2332	24	611	--
1994	31	253	38	1120	30	--	1156
1995	23	666	37	2194	23	666	--
1996	30	786	33	1062	30	--	2314
1997	16	583	26	2243	25	575	--

Table 5. Anova of Selected Soil Analysis in IPM Conservation Tillage Study.[1]

Source	pH	P	K	Ca	Mg
Block	**	**	**	**	**
Crop Sys	**	**	ns	**	**
Depth	**	**	**	**	**
Crop Sys ×depth	**	ns	ns	**	**

[1] pH was measured in water, P, K, Ca and Mg were extracted by Mehlich-1.

Table 6. Effect of Cropping Systems on Soil Analysis in IPM Conservation Tillage Study.

Cropping system	pH	P	K	Ca	Mg
	-----------------------PPM--------------------				
1	6.0 b	21 a	47	226 b	41 b
2	6.2 a	10 b	46	287 a	58 a
3	5.9 b	18 a	41	236 b	45 b

Within columns, any means followed by the same letter aree not significantly different. No letter shown when ANOVA indicates no significant difference at P = 0.05 level.

Table 7. Effect of Depth on Soil Analysis in IPM Conservation Tillage Study.

Depth	pH	P	K	Ca	Mg
0-3	6.6 a	27 a	45 b	455 a	97 a
3-6	6.3 b	24 ab	38 bc	214 c	42 b
6-9	5.8 cd	21 b	35 c	144 d	27 c
9-12	5.7 d	14 c	39 bc	183 c	30 c
12-16	5.9 c	01 d	61 a	250 b	44 b

Within columns, any means followed by the same letter aree not significantly different. No letter shown when ANOVA indicates no significant difference at P = 0.05 level.

Table 8. Crop Yield for RDC Conservation Tillage Study Rotation 1.

TRITICALE BU/A					
Tillage	1987	1988	1989	1990	1991
Strip-Till	----	----	20c	39b	20c
No-Till	----	----	15c	38b	19c
Strip-Till Burn	----	----	23b	56a	25b
Moldboard Burn	----	----	34a	53a	30a

COTTON LINT LB/A					
Tillage	1987	1988	1989	1990	1991
Strip-Till	----	583b	----	798	----
No-Till	----	533b	----	838	----
Strip-Till Burn	----	530b	----	942	----
Moldboard Burn	----	754a	----	829	----

SOYBEANS BU/A					
Tillage	1987	1988	1989	1990	1991
Strip-Till	----	----	30	—	40
No-Till	----	----	31	----	37
Strip-Till Burn	----	----	37	----	37
Moldboard Burn	----	----	33	----	39

Within columns, any means followed by the same letter aree not significantly different. No letter shown when ANOVA indicates no significant difference at P = 0.05 level.

Table 9. Crop Yield for RDC Conservation Tillage Study Rotation 2.

TRITICALE BU/A					
Tillage	1987	1988	1989	1990	1991
Ridge Plant	39	35	24c	33	20ab
No-Till	39	38	30b	29	18b
Strip-Till	43	43	31b	27	19b
Moldboard	48	43	37a	32	25a

COTTON LINT/A					
Tillage	1987	1988	1989	1990	1991
Ridge Plant	767	----	527ab	----	769
No-Till	760	----	380b	----	717
Strip-Till	719	----	629ab	----	678
Moldboard	852	----	728a	----	841

SOYBEANS BU/A					
Tillage	1987	1988	1989	1990	1991
Ridge Plant	----	27b	----	11b	----
No-Till	----	33ab	----	18a	----
Strip-Till	----	35ab	----	18a	----
Moldboard	----	41a	----	22a	----

Within columns, any means followed by the same letter aree not significantly different. No letter shown when ANOVA indicates no significant difference at P = 0.05 level.

Table 10. Effect of Tillage and Chemigation on Crop Yield in Abac Wheat-peanut-wheat-cotton Rotation.

	Crop					
	Wheat, Bu/A		Peanut, lb/A		Cotton, Lint lb/A	
Tillage	Chemigate	Conventional	Chemigate	Conventional	Chemigate	Conventional
1994						
Moldboard	49		1538	1740		
Strip-Till			1481	1300		
Subsoil-Till			1592	1350		
No-Till			1631	1517		
1995						
Moldboard	38	40			997 a	863 a
Strip-Till	40	36			908 a	691 ab
Subsoil-Till	39	43			769 b	865 a
No-Till	41	45			737 b	648 b
1996						
Moldboard	35	35	3523 a	3615 a		
Strip-Till	30	30	2986 ab	2955 bc		
Subsoil-Till	35	35	2864 b	3467 ab		
No-Till	29	28	2639 c	2530 c		
1997						
Moldboard	37 a	29			815 a	706 a
Strip-Till	32 ab	23			682 b	704 a
Subsoil-Till	30 b	26			468 c	590 b
No-Till	28 b	30			353 d	403 c

Within columns and years, any means followed by the same letter aree not significantly different. No letter shown when ANOVA indicates no significant difference at P = 0.05 level.

Table 11. Effect of Tillage and Chemigation on Crop Yield in Abac Wheat-cotton-wheat-peanut Rotation.

	Crop					
	Wheat, Bu/A		Peanut, lb/A		Cotton, Lint lb/A	
Tillage	Chemigate	Conventional	Chemigate	Conventional	Chemigate	Conventional
1994						
Moldboard	55	53			162 c	121 b
Strip-Till					377 b	234 a
Subsoil-Till					335 b	313 a
No-Till					539 a	367 a
1995						
Moldboard	36	36	2434	2835 a		
Strip-Till	38	35	2479	2660 a		
Subsoil-Till	38	38	2075	1826 b		
No-Till	38	36	2254	2516 a		
1996						
Moldboard	46 a	35 ab			1188 a	1169 a
Strip-Till	29 ab	44 a			986 b	1152 a
Subsoil-Till	39 b	39 a			829 b	834 b
No-Till	29 c	28 b			834 b	840 b
1997						
Moldboard	32 a	31 a	1652	1793		
Strip-Till	29 ab	31 a	1504	2124		
Subsoil-Till	26 bc	28 ab	1623	1869		
No-Till	23 c	25 b	1833	1906		

Within columns and years, any means followed by the same letter aree not significantly different. No letter shown when ANOVA indicates no significant difference at P = 0.05 level.

Table 12. Effect of Tillage and Chemigation on Crop Yield in Bowen Wheat-peanut-wheat-cotton Rotation.

	Crop					
	Wheat, Bu/A		Peanut, lb/A		Cotton, Lint lb/A	
Tillage	Chemigate	Conventional	Chemigate	Conventional	Chemigate	Conventional
1994						
Moldboard	50	51	1329 a	1220 a		
Strip-Till			1092 a	610 b		
Subsoil-Till			730 b	661 b		
No-Till			548 b	722 b		
1995						
Moldboard	31	35			890 a	981 a
Strip-Till	35	37			581 b	736 b
Subsoil-Till	32	34			615 b	750 b
No-Till	33	31			489 c	632 b
1996						
Moldboard	44 a	38 a	2628	2897 a		
Strip-Till	28 c	33 ab	2719	2660 ab		
Subsoil-Till	33 b	29 b	2414	2283 b		
No-Till	18 d	29 b	2403	2261 b		
1997						
Moldboard	22 a	22			734 a	735 a
Strip-Till	19 ab	21			764 a	588 ab
Subsoil-Till	15 b	23			580 b	487 bc
No-Till	16 b	23			474 b	335 c

Within columns and years, any means followed by the same letter aree not significantly different. No letter shown when ANOVA indicates no significant difference at P = 0.05 level.

Table 13. Effect of Tillage and Chemigation on Crop Yield in Bowen Wheat-cotton-wheat-peanut Rotation.

	Crop					
	Wheat, Bu/A		Peanut, lb/A		Cotton, Lint lb/A	
Tillage	Chemigate	Conventional	Chemigate	Conventional	Chemigate	Conventional
1994						
Moldboard	52	50			743a	434
Strip-Till					646a	330
Subsoil-Till					371b	440
No-Till					349b	305
1995						
Moldboard	37	41a	748b	1035ab		
Strip-Till	36	31b	1746a	1517a		
Subsoil-Till	37	34b	1688a	1198ab		
No-Till	30	31b	1165b	966b		
1996						
Moldboard	31a	40a			921a	881a
Strip-Till	29ab	25b			909a	895a
Subsoil-Till	24b	22b			909a	678b
No-Till	22b	23b			685b	812ab
1997						
Moldboard	18	18	1361b	1477ab		
Strip-Till	17	16	2120a	2124a		
Subsoil-Till	17	21	2142a	1369bc		
No-Till	21	22	1532a	1234c		

Within columns and years, any means followed by the same letter aree not significantly different. No letter shown when ANOVA indicates no significant difference at P = 0.05 level.

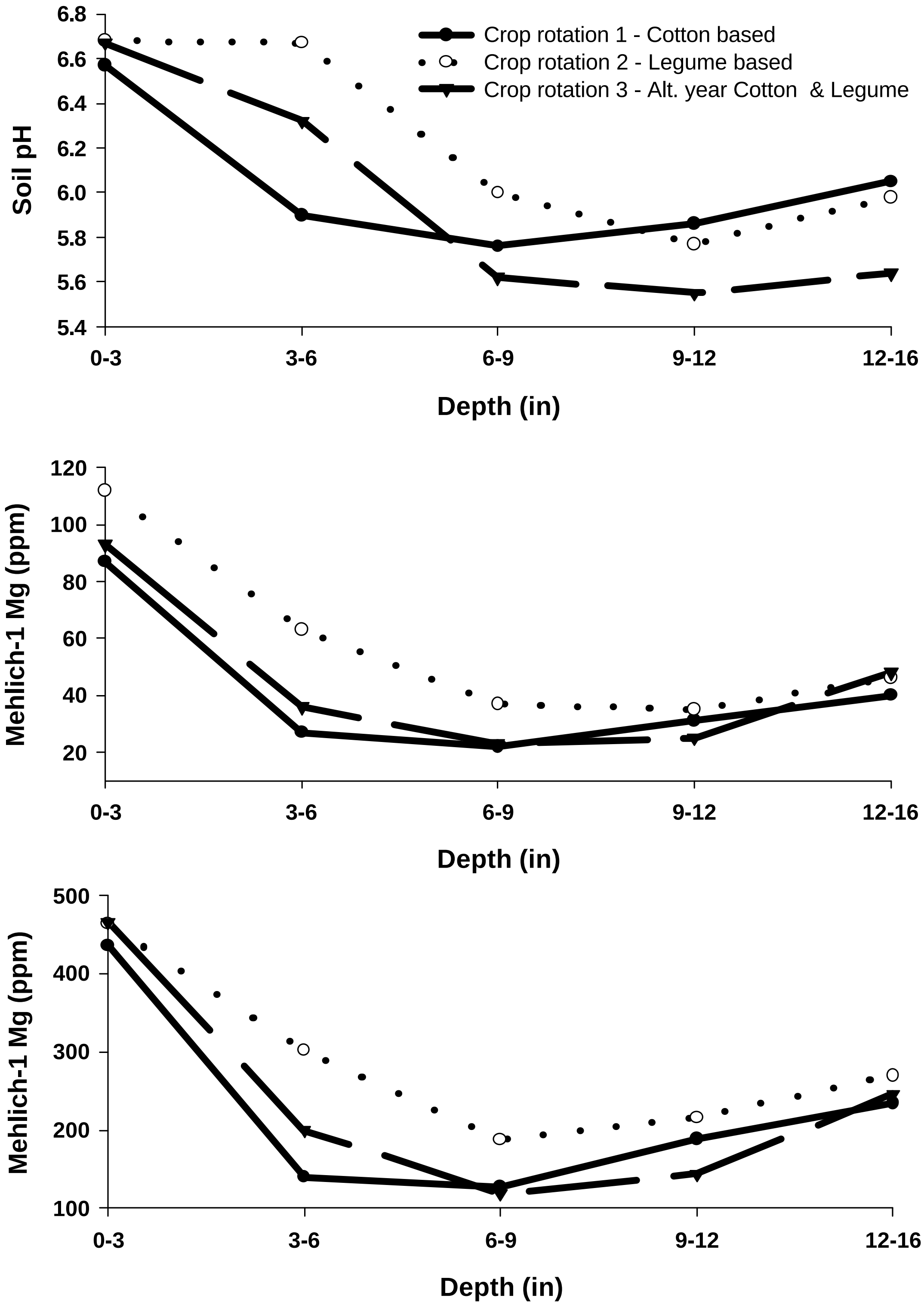


Fig. 1. Interaction of cropping system and soil depth on pH, Ca and Mg in the IPM Conservation Tillage Study (see Table 1 for full crop rotation descriptions from 1987 to 1997.

PEANUT CULTIVAR RESPONSE WHEN PLANTED IN EITHER TWIN OR SINGLE ROW PATTERNS BY STRIP-TILLAGE OR NO-TILLAGE METHODS

J. A. Baldwin[1], A. K. Culbreath[2], S. Jones[3]

AUTHORS: [1]Professor, Crop and Soil Sciences Department and [2]Professor, Plant Pathology Department, University of Georgia, CAES Tifton Campus, Post Office Box 1209, Tifton, GA 31794; [3]Superintendent, Southwest Georgia Branch Experiment Station, Plains, GA 31780. Corresponding author: J. A. Baldwin Email: jbaldwin@arches.uga.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95, Athens, GA.

Abstract. The object of this experiment was to determine the response of peanut when planting in single or twin row patterns by strip-tillage or no-tillage methods. During 1997 and 1998 the peanut cultivars 'Georgia Green' and 'Georgia Runner' or 'Georgia Green' and 'Georgia Bold' (*Arachis hypogaea L.*) were planted in 9.5 or 9.0 inch twin row patterns versus 36 inch single row at the same seeding rate (6 seed/foot single or 3 seed/foot twin). The peanuts were planted into mowed cotton stubble without a cover crop by either strip-tillage or no-tillage methods.

During 1997, there was no difference in grade (TSMK) or tomato spotted wilt incidence (TSWV) between strip tillage and no tillage. 'Georgia Green' had significantly less TSWV than 'Georgia Runner.' There was a significant yield increase for twin row over single row. In 1998, there was no response to tillage method or row pattern. 'Georgia Green' did have significantly less TSWV than 'Georgia Bold.' In both years, there was a trend toward higher yields with the twin row pattern and digging losses would attribute to the lack of response to the twin row patterns during 1998.

INTRODUCTION

Conservation tillage practices continue to increase for Georgia farmers who are looking for ways to reduce production costs through labor and time savings. They are also seeking erosion control, better water holding capacity and less runoff. There have been several studies that show that reduced tillage peanut production has had inconsistent results when compared to conventional peanuts (Cheshire et al. 1985, Colvin et al. 1988, Hartzog and Adams 1989, Williams et al. 1997). There have also been studies to show that there are fewer insect pests and less tomato spotted wilt virus (TSWV) when peanuts are planted by reduced tillage methods versus conventional planting (Brandenburg et al. 1998, Baldwin and Hook 1998).

Baldwin et al. (1997) demonstrated that six peanut cultivars had improved yield, grade, and TSWV when planted by twin row patterns compared to single row when planted by conventional methods.

The objective of this study was to compare the response of three peanut cultivars in yield, grade, and TSWV incidence when planted in twin or single row patterns by strip-tillage or no-tillage methods.

MATERIALS AND METHODS

The plot area for the study was a Greenville sandy loam soil type located at the South West Georgia Branch Experiment Station at Plains, Georgia. The objective was to establish a series of long term rotational and tillage studies primarily looking at the effects of tillage and rotational crops on the yield and grade of peanuts produced. In the fall of 1994, all plots were disked, subsoiled and planted to a wheat cover crop. In the spring of 1995, the entire area was planted to no-till corn with no irrigation. Yields over the plot area averaged 75 bushels/acre. In 1996, the area was divided into three two acre blocks to initiate a corn, cotton, peanut rotation with each crop planted by either strip-till or no-till methods with supplemental irrigation. Yields in 1996 were strip-till corn, 159 bushels/acre; no-till corn, 163 bushels; strip-till cotton, 2.5 bales/acre; no-till cotton, 2.28 bales/acre, strip-till peanuts, 4407 pounds/acre and no-till peanuts, 3463 pounds/acre.

During 1997, the peanut cultivars 'Georgia Green' or 'Georgia Runner' were planted by strip-till or no-till methods in either single 36 inch row or twin 9.5 inch row patterns following cotton stubble with no cover crop. The entire plot area was following cotton in 1996. The cotton stalks were mowed and the area left fallow with no cover crop during the fall and winter of 1996. One quart/acre of Roundup herbicide was sprayed prior to planting as a burndown. One pint of Starfire plus 1 quart/acre of Prowl was applied preplant and 300 pounds/acre of 3-18-9 analysis fertilizer was applied to the surface on March 4, 1997. A six row KMC strip-till unit was utilized to mark off rows prior to planting the strip-till plots. A two row Monosem planter was used to plant each cultivar in either 36 inch or 9.5 inch twin row following the in-row subsoil KMC unit. Temik (aldicarb) was applied at 4.3 pounds/acre rate in-furrow. The no-till plots were planted with the Monosem planters fitted with a Yetter ripple coulter to cut through any existing residue. Each cultivar was planted at 6 seed/foot of row for single row or 3 seed/foot of row for the twin row to obtain the same seeding rate/acre. All plots were a randomized complete block design with three replications. Main plots were tillage and subplots were row patterns and cultivars. All plots were planted on May 8, 1997; dug with a UFT digger set up for twin row with a 30 inch blade and 30 degree frog on October 3, 1997; and harvested on October 7, 1997. Plot yields were corrected to 7% moisture and graded according to FSIS standards.

During 1998, the peanut cultivars 'Georgia Green' and 'Georgia Bold' were planted. One quart/acre of Roundup herbicide was sprayed prior to planting as a burndown. One pint of Starfire plus one quart/acre of Prowl was applied preplant and 300 pounds/acre of 3-18-9 analysis fertilizer was applied to the surface on March 7, 1998. A six row KMC strip-till unit was utilized to mark off rows prior to planting the strip-till plots. A two row Monosem planter was used to plant each cultivar in either 36 inch or 9 inch twin row following the in-row subsoil KMC unit. Temik (aldicarb) was applied at 4.3 pounds/acre rate in-furrow. The no-till plots were planted with the Monosem planters fitted with a Yetter ripple coulter and row cleaner to cut through any existing residue. Each cultivar was planted at 6 seed/foot of row for single row or 3 seed/foot of row for the twin row to obtain the same seeding rate/acre. All plots were a randomized split plot design with three replications. Main plots were tillage and subplots were row patterns and cultivars. All plots were planted on May 6, 1998; dug with a standard KMC two row digger on September 25, 1998; and harvested on September 28, 1998. Plot yields were corrected to 7% moisture and graded according to FSIS standards.

RESULTS AND DISCUSSION

Yield, grade, and TSWV incidence of peanut cultivars in response to tillage and row pattern are found in Table 1 for 1997. There was no difference in grade or TSWV incidence between strip tillage or no tillage. 'Georgia Green' had significantly less TSWV than 'Georgia Runner' at a sight which traditionally has had less TSWV than other areas of the state. There was a significant response to twin row over single row for yield (Table 1). The response of twin row over single would indicate that more studies need to be conducted. Even though not significant across cultivars and row patterns, there was a trend for increased yield and a reduction of TSWV of strip-till. Peanut yields averaged across the two varieties were 3960 lbs/acre and 3640 lbs/acre for strip-till versus no-till. The yields for twin row patterns were 4307 for strip-till and 3930 lbs/acre for no-tillage plots. Corn yields were 117 bu/acre for strip-till and 104 bu/acre for no-till. Cotton produced 1.89 bales/acre regardless of tillage type.

1998 yield, grade, and TSWV incidence of cultivars in response to tillage and row pattern are found in Table 2. There was no difference in yield, grade, or TSWV incidence between strip tillage and no tillage. 'Georgia Green' had significantly less TSWV than 'Georgia Bold' at a sight which traditionally has had less TSWV than other areas of the state. There was no significant response due to row pattern during 1998 compared to 1997 (Table 2). The soil was slightly wet at digging and a standard set digger was used in place of the digger modified for twin row patterns. Nine inch or wider twin row on a 36 inch outside row pattern should be dug with 30 inch blades and a 30 degree frog to reduce digging and harvest losses. A Poast-tolerant variety of corn was planted during 1998 and even under irrigation it yielded only 57 bu/acre on strip-till and 79 bu/acre by no-tillage planting methods. During 1998 the strip-till cotton yielded 1.9 bales/acre compared to 1.85 bales/acre for the no-tillage planted cotton.

ACKNOWLEDGMENT

We would like to thank the Georgia Seed Development Commission, Georgia Peanut Commission, Cargill Peanut, and KMC Corporation for providing financial or technical support to this study. A special thanks goes to the field technicians at the Southwest Branch Station for their efforts in making this study possible.

LITERATURE CITED

Baldwin, J.A. 1997. Yield, grade, TSWV incidence of several peanut cultivars when planted in twin versus single row patterns. Georgia Peanut Research Extension Report No. 98-2.

Baldwin, J.A. and J. Hook. 1998. Reduced tillage systems for peanut production in Georgia. Peanut Sci. 30:48.

Brandenburg, R.L., D.A. Herbert, Jr, G.A. Sullivan, G.C. Naderman, and S.F. Wright. 1998. The impact of tillage practices on thrips injury of peanut in North Carolina and Virginia. Peanut Sci. 25: 27-31.

Cheshire, J.M., Jr., W. L. Hargrove, C.S. Rothrock, and M.E. Walker. 1985. Comparison of conventional and no-tillage peanut production practices in central Georgia, pp. 82-86. In W.L. Hargrove, F.C. Boswell, and G.W. Langdale (eds) The Rising Hope of Our Land. Proc. South. Region No-till Conf., 16-17 Jul, Griffin, GA.

Colvin, D.L. and B.J. Brecke. 1988. Peanut cultivar response to tillage systems. Peanut Sci. 15:21-24.

Hartzog, D.L. and J.E. Adams. 1989. Reduced tillage for peanut production. Soil Tillage Res. 14:85-90.

Williams, E.J., J.L. Davidson Jr., and S. Hilton 1997. Effect of selected reduced tillage practices on peanut yield, grade, and disease incidence. Georgia Peanut Research Extension Report No. 98-2.

Wright, F.S. and D.M. Porter. 1995. Conservational tillage and cultivar influence on peanut production. Peanut Sci. 22:120-124.

Table 1. Yield and Grade Response of 'Georgia Green' and 'Georgia Runner' to Row Patterns and Tillage Method. SW Branch Station, Plains 1997.

	YIELD	TSMK	OK	TSWV
	lb/acre	--------%---------		
No-till	3640	75	2	16
Strip-till	3960	76	2	12
LSD	NS	NS	NS	NS
'Georgia Green'	3860	76	2.5	8*
'Georgia Runner'	3740	76	2.4	20
LSD	NS	NS	NS	3
Single	3580*	75	2.5	14
Twin	4020	76	2.4	14
LSD	381	NS	NS	NS

* Significant at P≤ .05

Table 2. Yield and Grade Response and 'Georgia Green' and 'Georgia Bold' to Row Patterns and Tillage Method. SW Branch Station, Plains 1998.

	YIELD	TSMK	OK	TSWV
	lb/acre	--------------%------------		
No-till	3525	75.0	2.5	25
Strip-till	4015	75.2	2.3	31
LSD	NS	NS	NS	NS
'Georgia Green'	3850	75.0	2.8	22*
'Georgia Bold'	3690	75.0	2.0	34
LSD	NS	NS	NS	NS
Single	3860	74.7	2.5	30
Twin	3680	75.4	2.3	27
LSD	NS	NS	NS	NS

* Significant at P#.05

NITROGEN AND TILLAGE COMPARISONS OF CONVENTIONAL AND ULTRA-NARROW ROW COTTON

D. L. Wright[1], P. J. Wiatrak[1], J. A. Pudelko[2], B. Kidd[1], and W. Koziara[2]

AUTHORS: [1]North Florida Research and Education Center, Quincy, FL 32351; [2]Agriculture University Institute of Soil Culture and Plant Production, Mazowiecka 45/46 60-623 Poznan, Poland.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*. Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. This research was conducted in 1997 and 1998 on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) located at the North Florida Res. and Educ. Center (NFREC), Quincy, FL. The objective was to compare 36" row-spaced cotton planted with a strip-till planter to ultra-narrow row cotton (UNR) with 7" row width planted with a Great Plains no-till drill (both planted in minimum and conventional tillage). Three N rates (0, 60, 120 lb N acre^{-1}) were applied in 1997and four (0, 60, 120, and 180 lb a.i. N acre^{-1}) were applied in 1998. Increased N rates generally increased number of bolls plant^{-1} for both row treatments with higher increase of boll number in conventional row width as compared to UNR. Significantly higher yields of cotton were obtained for UNR as compared to conventional rows in both years with the highest yield on UNR at 120 lb N acre^{-1} in 1997 and with no N in 1998 due to hard lock.

INTRODUCTION

Cotton production increased rapidly in Florida, from about 12,000 acres in 1985 to 98,000 acres in 1996 with the production of 130,000 Bales in 1996. According to Touchton and Reeves (1988), conservation tillage systems have a beneficial effect on cotton production in the sandy coastal plain soils of the southeastern states, but the natural formation of tillage pans has been recognized as a limiting in these soils. Torbert and Reeves (1991) showed that, in years of below-normal rainfall during the growing season, strip tillage (no-till plus in row subsoiling) was found to maintain the highest seed cotton yield. Fertilizer-N application had no effect on cotton yields in an extremely dry growing season, suggesting that the beneficial effect of N fertilizer may be limited under such conditions. Studies conducted near Stoneville, MS, on UNR cotton showed no effect of row spacing on seed cotton yields (Heitholt et al., 1993). The results suggest that some agronomic traits of cotton might be expected to be similar regardless of row spacing; therefore, management practices, such as rate and timing of defoliation chemicals, do not necessarily need modification in narrow row systems. According to the study conducted by Torbert and Reeves (1994) increasing N application increased cotton biomass and decreased lint percentage. In a dry year, tillage had no significant effects on cotton yield components. Above-normal rainfall and strip-till with no-traffic treatment gave the highest seed cotton yield of 2445 lb acre^{-1} and the greatest fertilizer N uptake efficiency (35%). Results indicate that the detrimental effects of traffic on N uptake efficiency may be reduced with conservation tillage systems and that higher fertilizer N application rates may not be needed for conservation tillage practices such as strip-till in Coastal Plain soils.

The objectives of this research were to compare minimum and conventional tillage for cotton planted in 36" and 7" row spacings with different N rates on cotton.

MATERIALS AND METHODS

These studies were conducted on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) located on the NFREC, Quincy, FL in 1997 and 1998. The experimental design was a randomized complete block design, with four replications. Plot size was 40 ft x 12 ft for conventional planted cotton and 40 ft x 20 ft for UNR cotton in both years. Paymaster 1220 Roundup Ready/BG cotton was planted in UNR following wheat with the Great Plains No-till drill at 2 seeds ft^{-1} of row (7 inch row spacing) and with a Brown Row-till implement and KMC planters at 3-4 seeds ft^{-1} of row (36 inch row spacing). Cotton was sidedressed with 60 and 120 lb N acre^{-1} (treatments with the rate of 180 lb N acre^{-1} got only 120 lb N acre^{-1}) using Gandy Fertilizer spreader on UNR cotton and FP Fertilizer spreader on 36 inch rows. An additional rate of 60 lb N acre^{-1} was applied on the treatment with 180 lb N acre^{-1} two weeks later. Cotton was broadcast sprayed with Roundup @ 1 pt acre^{-1} + Induce @ pt 25 gal^{-1} H_2O at the 4th node stage and then directed sprayed on an as need basis. Insects were scouted and pest controlled using standard pest management practices. Pix plant growth regulator was applied at 12 oz. per acre two times two weeks apart. Cotton was defoliated with Prep @ 2 pt. acre^{-1} + Harvade @ .5 pt. acre^{-1} and Roundup @.5 pt. acre^{-1}. Cotton was picked from the UNR section of the experiment with a stripper harvester and the 36 inch wide cotton rows were picked with a International 782 spindle picker. The lint cotton yield, from the sections picked with a spindle picker, were calculated as 38% of the seed cotton yield and stripper harvested was calculated as 31% of seed cotton yield.

Data were analyzed using SAS (1989) by analysis of variance, and means were separated using Fisher's Least Significant Difference Test at the 5% probability level.

RESULTS AND DISCUSSION

In 1997, plant population averaged three times more for UNR cotton as compared to conventional row widths (Table 1). Significantly taller plants occurred on the conventional rows as compared to UNR (3.76 and 2.53 ft, respectively) and heights increased with higher N rates (3.00, 3.08, and 3.35 ft. at 0, 60, and 120 lb N acre^{-1}) (Table 2). Higher rates of N generally increased number of bolls for both row widths with higher boll number per plant in conventional row width at 0, 60, and 120 lb N acre^{-1} (10.2, 13.9, and 14.2 boll plant^{-1}) as compared to UNR (3.9, 4.7, and 5.8 boll plant^{-1}) (Table 3). In 1997, lint yields were significantly higher on UNR than conventionally planted cotton (1076 and 786 lb acre^{-1}, respectively) (Table 4) and were also higher at the application of 120 lb N acre^{-1} as compared to 0 and 60 lb N acre^{-1} (1041, 876, and 875 lb acre^{-1}, respectively). There was no significant influence of tillage on the yield in either year. In 1998, plants were taller from 7" row spacing as compared to 36" row spacing (3.64 and 3.33 ft, respectively) (Table 5). Plants were also taller at higher N rates of 120 and 180 lb acre^{-1} (3.64 and 3.73 ft, respectively) than N rates of 60 or 0 lb acre^{-1} (3.44 and 3.12 ft, respectively). In 1998, height to node ratio was higher for the UNR cotton as compared to the conventional row width cotton (Table 6). There was a tendency for taller plants with higher N rates. Lint yields were low from both row widths due to hard lock problems. There was over twice as many bolls per plant in 36" row width as compared to UNR (Table 7). Total hard lock bolls for the study was 84% (Table 8) averaged over the entire study, resulting in low yields. However, yield of UNR cotton averaged almost three times more lint than 36" row width (Table 9). Nitrogen rate decreased yield in each case on both row widths due to late rains which activated the N late causing late growth and green bolls and more hard lock problems. UNR cotton planted either no-till or conventional shows much potential for more yield than conventional row width cotton but much work needs to be done to answer fertility, defoliation, marketing and ginning questions.

Table 1. Influence of Row Width and N Rate on Plant Population of Cotton at NFREC, Quincy, Fl in 1997.

Row Width	Nitrogen rate (lb acre^{-1})			Avg
	0	60	120	
in.	---------- thousands acre^{-1} ----------			
36	29.0	33.9	30.7	31.2
7	93.6	103.3	90.3	95.7
Avg.	61.3	68.6	60.5	63.5

$LSD_{(0.05)}$ for row width 14.6 $LSD_{(0.05)}$ for nitrogen rate NS
$LSD_{(0.05)}$ for row width x nitrogen rate NS

CONCLUSIONS

18. Number of bolls per plant generally increased with higher N rates and were higher on plants from conventional rows than UNR.
19. Higher yields of cotton were obtained at higher N rates in 1997 and were opposite due to drought and hard lock bolls in 1998.
20. Significantly higher yields were obtained on UNR as compared to conventional row widths in both years.

REFERENCES

Heitholt, J. J., W. T. Pettigrew, and W. R. Meredith, Jr. 1993. Growth, boll rate, and fiber properties of Narrow row cotton. Agron. J. 85:590-594.

SAS Institute Inc. 1989. SAS/STAT user's guide,version 6, 4th ed., vol. 1 and 2. SAS Institute Inc., Cary,NC. 1789 pp.

Torbert, H. A. and D. W. Reeves. 1991. Yield response and nitrogen requirement of cotton as affected by tillage and traffic. pp. 98-102. *In* Proc. Southern Conservation Tillage Conf. June 18-20, North Little Rock, AR.

Torbert H. A. and D. W. Reeves. 1994. Fertilizer nitrogen requirements for cotton production as affected by tillage and traffic. Soil Sci. Soc. Am. J. 58(5): 1416-1423.

Touchton, J. T. and D. W. Reeves. 1988. A Beltwide look at conservation tillage for cotton. pp. 36-41. *In* Proc. 1988 Beltwide Cotton Production Conf., Highlights of Cotton Production Res. Conf. Jan. 3-8, New Orleans, LA. National Cotton Council of America, Memphis, TN.

Table 2. Influence of Row Width and N Rate on Plant Height of Cotton at NFREC, Quincy, FL in 1997.

Row width	Nitrogen rate (lb acre^{-1})			Avg.
	0	60	120	
in.	------------------ ft -------------------			
36	3.53	3.77	3.97	3.76
7	2.47	2.40	2.73	2.53
Avg.	3.00	3.08	3.35	3.14

$LSD_{(0.05)}$ for row width 0.197 $LSD_{(0.05)}$ for nitrogen rate 0.241
$LSD_{(0.05)}$ for row width x nitrogen rate NS

Table 3. Influence of Row Width and N Rate on Number Bolls on Cotton at NFREC, Quincy, FL in 1997.

Row width	Nitrogen rate (lb acre^{-1})			Avg.
	0	60	120	
in.	--------------- bolls plant^{-1} --------------			
36	10.2	13.9	14.2	12.8
7	3.9	4.7	5.8	4.8
Avg.	7.0	9.3	10.0	8.8

$LSD_{(0.05)}$ for row width 1.02 $LSD_{(0.05)}$ for nitrogen rate 1.25
$LSD_{(0.05)}$ for row width x nitrogen rate ns

Table 4. Influence of Row Width, Tillage, and N Rate on Lint Yields of UNR Vs. Conventionally Planted Cotton at NFREC, Quincy, FL in 1997.

N rate	Row spacing - 7 inch			Row spacing - 36 inch			Avg.
	No-till	Conv.	Avg. (N rate)	Strip-till	Conv.	Avg. (N rate)	
lb acre^{-1}	lb lint acre^{-1}			lb lint acre^{-1}			
0	827	1176	1001	826	677	751	876
60	983	1046	1014	772	698	735	875
120	1196	1227	1212	788	953	871	1041
Avg.	1002	1150	1076	795	776	786	931

$LSD_{(0.05)}$ for row spacing = 97.7; $LSD_{(0.05)}$ for tillage = ns; $LSD_{(0.05)}$ for N = 119.6; $LSD_{(0.05)}$ for row spacing x tillage = ns; $LSD_{(0.05)}$ for row spacing x N = ns; $LSD_{(0.05)}$ for tillage x N = ns; $LSD_{(0.05)}$ for row spacing x tillage x N = 293.3.

Table 5. Influence of Row Width and N Rate on Plant Height of Cotton at NFREC, Quincy, FL in 1998.

Row width	Nitrogen rate (lb acre^{-1})				
	0	60	120	180	Avg
in.	--------------------- ft ---------------------				
36	2.91	3.27	3.57	3.56	3.33
7	3.33	3.61	3.72	3.90	3.64
Avg.	3.12	3.44	3.64	3.73	3.49

$LSD_{(0.05)}$ for row width = 0.097; $LSD_{(0.05)}$ for nitrogen rate = 0.138; $LSD_{(0.05)}$ for row width x nitrogen rate = NS

Table 6. Influence of Row Width and N Rate on Height to Node Ratio (Hnr) for Cotton at NFREC, Quincy, FL in 1998.

N rate	Row width (inch)		
	7	36	Avg.
lb acre^{-1}	ratio		
0	2.34	2.22	2.28
60	2.40	2.28	2.34
120	2.56	2.33	2.45
180	2.70	2.35	2.53
Avg.	2.50	2.29	2.40

$LSD_{(0.05)}$ for row width = 0.074; $LSD_{(0.05)}$ for N rate = NS; $LSD_{(0.05)}$ for row width x N rate = NS.

Table 7. Influence of Row Width and N Rate on Boll Number per Plant at NFREC, Quincy, FL in 1998.

N rate	Row width (inch)		
	7	36	Avg.
lb acre^{-1}	----------- bolls plant^{-1} -----------		
0	7.7	17.3	12.5
60	9.1	19.6	14.4
120	8.2	18.0	13.1
180	6.7	20.0	13.4
Avg.	7.9	18.7	13.4

$LSD_{(0.05)}$ for row width = 1.60; $LSD_{(0.05)}$ for N rate = NS; $LSD_{(0.05)}$ for row width x N rate = NS.

Table 8. Influence of Row Width and N Rate on Percent Hard Lock Bolls on Cotton at NFREC, Quincy, FL in 1998.

N rate	Row width (inch)		
	7	36	Avg.
lb acre^{-1}	---------------------%-----------------		
0	77.7	85.9	81.8
60	85.9	81.3	83.6
120	82.7	86.9	84.8
180	84.7	91.1	87.9
Avg.	82.7	86.3	83.9

$LSD_{(0.05)}$ for row width = NS; $LSD_{(0.05)}$ for N rate = NS; $LSD_{(0.05)}$ for row width x N rate = NS.

Table 9. Influence of Row Width and N Rate on Lint Cotton Yield at NFREC, Quincy, FL in 1998.

N rate	Row width (inch)		
	7	36	Avg.
lb acre^{-1}	-------- lb acre^{-1} --------		
0	714	224	469
60	577	228	403
120	548	200	374
180	522	156	339
Avg.	590	202	396

$LSD_{(0.05)}$ for row width = 29.8; $LSD_{(0.05)}$ for N rate = 42.1; $LSD_{(0.05)}$ for row width x N rate = 59.6.

IMPACT OF COMPOST AND TILLAGE ON SWEET CORN YIELD, SOIL PROPERTIES, AND NEMATODES

J. D. Greenwood[1], R.N. Gallaher[2], and R. McSorley[3]

AUTHORS: [1]Graduate Research Assistant, Department of Agronomy, [2]Professor, Department of Agronomy, and [3]Professor, Department of Entomology and Nematology, Institute Food & Agriculture Science, University of Florida, Gainesville, FL 32611. Corresponding Author: J.D. Greenwood, Agronomy Dept., PO Box 110730, University of Florida, Gainesville, FL 32611-0730; E-mail: bahia@ufl.edu ;
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture,* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. In 1996, an estimated 840,000 tons of municipal solid waste compost was produced in Florida. The objectives of this study were to assess the impact of previous applications of yard waste compost (YWC), new applications of YWC, and three fertilizer rates on sweet corn (*Zea mays*) yield, soil properties, and plant-parasitic nematodes. Three old residual YWC treatments (YWC incorporated, YWC mulch, control) were split with two new YWC treatments (0 versus 120 ton/acre). These split plots were further split and received three fertilizer treatments (full extension recommendation, one-half extension recommendation, and control that received no fertilizer). Therefore, this site in 1998 was a split-split plot with the old YWC main treatments in a randomized complete block design with four replications. On 2 April, 'Silver Queen' sweet corn was planted approximately one month after the application of new YWC. Yield data were collected as well as nematode data from soil samples at planting and near harvest time. Yield was equal among all the old YWC treatments at the full extension fertilizer rate, but was greater for the YWC residual treatments when extension fertilizer recommendations was reduced. New YWC treatments did not significantly impact yield. Extension fertilizer recommendations can possibly be reduced by one-half under the old YWC additions, whereas the control required the full recommendation. Bulk density significantly decreased from both old YWC and new YWC treatments. At field capacity, percent soil water was the highest in the treatments containing old and new applications of YWC.

INTRODUCTION

Recent studies have shown that yard waste compost (YWC) applied to corn (*Zea mays* L.) cropping systems caused improvement in soil properties and some reductions in plant-parasitic nematodes, all highly correlated with increased corn yield (Gallaher and McSorley, 1994a; 1994b; 1994c; 1994d; 1995a; 1995b; 1996; McSorley and Gallaher, 1995; 1996a; 1996b). Corn yield increases are traced to improvement in soil properties from application of YWC (Gallaher and McSorley, 1994c; 1994d; 1996). For example, soil water storage at planting time was increased when YWC was incorporated into the soil and increased even more when YWC was used as mulch (Gallaher and McSorley, 1994c). The objectives of this study were to assess the impact of previous applications of YWC, new applications of YWC, and three fertilizer rates on sweet corn yield, soil properties, and plant-parasitic nematodes.

MATERIALS AND METHODS

The YWC experiment was superimposed on an existing experiment located on the Green Acres Agronomy Field Research Laboratory in Alachua County. The original experimental design was a randomized complete block with four replications. The YWC used in this study was < 1 in sieve size. The Green Acres study was begun in 1993 and the soil type was an Arredondo loamy sand (loamy, siliceous, hyperthermic, Grossarenic Paleudult) (Soil Survey Staff, 1994). The incorporated and mulch treatments received 120 ton YWC/acre each year from 1993 to 1996 for a total of 480 ton YWC/acre. The control treatment received no YWC any year at this site. Sweet corn was grown in 1997 to observe the residual effect of previous treatments on yield (Gallaher, 1998; Gallaher, et al., 1998).

On 2 April 1998, 'Silver Queen' sweet corn was planted approximately one month after the application of new YWC. The old residual YWC treatments were split in 1998 and either received 120 ton new YWC/acre or no new YWC. These latter new YWC treatments were split again and received either the full extension fertilizer recommendation, one-half the extension recommendation, or no fertility (control). The extension fertility recommendation was 150-0-100, lb N, P_2O_5, K_2O per acre and was based on the old YWC control treatment. Nitrogen (NH_4NO_3) was applied in three equal splits and K (KCl) in two equal splits. Therefore the experimental site was a split-split plot experiment in 1998 with four replications. The experimental area was irrigated as necessary and insecticide was applied as needed.

Soil samples were taken to determine bulk density and water content at harvest following irrigation to field capacity. Bulk density measurements were obtained using the core method and water content was determined by gravimetry with oven drying (Blake, 1965).

Nematode samples were collected at planting and harvest by removing 6 soil cores per subplot. Soil samples were analyzed for nematodes from 100-cm^3 subsamples (Jenkins, 1964). Fresh sweet corn ears were harvested by hand from the two middle rows of each plot, graded according to USDA standards for green corn and weighed (Anonymous, 1954). Completed data was statistically analyzed, followed by mean separation with Duncan's New Multiple Range Test and/or LSD using MSTAT (1985). Graphs were produced using CA-CRICKET Graphics (1990).

RESULTS AND DISCUSSION

Yield

An interaction occurred between old YWC treatments and extension fertilizer recommendation treatments (table 1). Yield was equal among all the old YWC treatments at the full extension fertilizer rate, but was greater for the YWC residual treatments when extension fertilizer recommendations were reduced. New YWC treatments did not significantly impact yield. A 50% to 70% or more higher yield of fancy grade ears was found for both old YWC treatments when averaged across all new YWC treatments and all fertilizer levels, compared to the control treatment (Fig. 1). When averaged across all old and new YWC treatments, fancy grade ears required the full extension fertilizer recommendation (Fig. 2).

Soil data

Bulk density significantly decreased from both old YWC and new YWC treatments. The addition of new YWC to the old YWC incorporated treatment had a bulk density of 0.90 g/cc soil compared to the old YWC control that received YWC, with a bulk density of 1.40 g/cc soil. The highest bulk density was for the old control treatment that had never received any YWC, which was 1.61 g/cc soil. Soil water was highest in the treatments containing both old and new YWC at field capacity (table 2).

Nematodes

All nematodes increased during the growth period of sweet corn (table 3). Root-knot nematode numbers were greatest in YWC-treated plots compared to the control while the reverse was true for lesion nematodes.

SUMMARY

Recycling of urban plant debris as yard waste compost (YWC) requires extensive research in Florida and the USA. This research investigated the use of YWC as a fertilizer amendment and its effect on soil quality and sweet corn yield. Data show that the effect of YWC is for sweet corn yields of fancy grade ears to increase by as much as 70%. Extension fertilizer recommendations can possibly be cut by one-half under these old YWC additions, whereas the control required the full recommendation. Soil quality is highly improved as evidenced by a large reduction in bulk density and by increase in soil water holding capacity of 70 to 150%, depending upon the old and new YWC treatment combination. The more favorable soil quality from addition of YWC resulted in increased corn yield. Greater numbers of root-knot nematode were associated with a more favorable soil environment. The healthier corn likely provided a good host environment for increased root-knot nematode numbers.

ACKNOWLEDGMENTS

The authors appreciate the technical assistance of Mr. Howard Palmer, Mr. Jim Chichester, and Mr. Walter Davis of the Agronomy Department and Mr. John Frederick of the Entomology and Nematology Department. This research was partially supported by a Florida Dept. of Environmental Protection Grant administered through the University of Florida, Inst. of Food and Agr. Sci., Center for Biomass Programs, Gainesville, Florida.

LITERATURE CITED

Anonymous. 1954. United States Standards for Grades of Green Corn. Source 19 FR 2221, Apr. 17, 1954. Redesignated at 42 FR 32514, June 27, 1977. U.S. Dept. of Agriculture, Food Safety and Quality Service, Washington, D.C.

Blake, G.R. 1965. Bulk Density. pp. 374-377 *In* C.A. Black (Ed.). Methods of Soil Analysis: Part I Physical and Mineralogical Properties, Including Statistics of Measurement and Sampling. Amer. Soc. Agron., Madison, WI.

CA-CRICKET Graph^{tm}. 1990. User's Guide for CA-CRICKET Graph for Microsoft Windows. Computer Associates, Software Superior Design, 10505 Sorrento Valley Road, San Diego, CA.

Gallaher, R.N. 1998. No-till organically grown vegetables. Abstract, American Soc. Agron. 90:57.

Gallaher, R.N., J.D. Greenwood, and R. McSorley. 1998. Sweet corn response to yard waste compost and lupin hay fertilizer treatments. pp. 28-31. *In* T.C. Keisling (Ed). Proc. 1998 Southern Conservation Tillage

Conference for Sustainable Agriculture. Special Report 186. Univ. of Arkansas Agric. Exp. Sta., Fayetteville, AK.

Gallaher, R.N., and R. McSorley. 1994a. Management of yard waste compost for soil amendment and corn yield. pp. 156-160. *In* P.J. Bauer and W.J. Busscher (eds.). Proc. 1994 Southern Conservation Tillage Conference for Sustainable Agriculture. USDA-ARS, Coastal Plains Soil, Water, and Plant Research Center, Florence, SC.

Gallaher, R.N., and R. McSorley. 1994b. Management of yard waste compost for soil amendment and corn yield. Proc. of the Composting Council's Fifth National Conference, Vista Hotel, Washington, DC. Nov. 16-18, 1994. The Composting Council, 114 South Pitt St. Alexandria, VA. 5:28-29.

Gallaher, R.N., and R. McSorley. 1994c. Soil water conservation from management of yard waste compost in a farmer's corn field. Agronomy Research Report AY-94-02, Agronomy Dept., Inst. Food & Agr. Sci, Univ. of Florida, Gainesville, FL.

Gallaher, R.N., and R. McSorley. 1994d. Change in soil properties, crop nutrition, nematode relationships and yield of corn and vegetables from yard wast compost. Summary Report for the Florida Composting Conference. pp. 38-39. Special Report sponsored by the Florida Dept. Of Agr. And Consumer Services, July, 21-22, 1994, Orlando, FL. Univ. of Florida Center for Biomass Programs, IFAS, Gainesville, FL.

Gallaher, R.N., and R. McSorley. 1995a. No-tillage field corn and vegetables using yard waste compost. pp. 16-18. *In* W.L. Kingery and Normie Buehring, (eds.). Proc. 1995 Southern Conservation Tillage Conference for Sustainable Agriculture. Special Bulletin 88-7, Mississippi Agricultural & Forestry Experiment Station, Mississippi State, MS.

Gallaher, R.N., and R. McSorley. 1995b. Conventional tillage and no-tillage vegetables using yard waste compost. Agronomy Research Report AY-95-01. Agronomy Dept., Inst. Food & Agr. Sci., Univ. of Florida, Gainesville, FL.

Gallaher, R.N., and R. McSorley. 1996. Soil properties, nematode densities, and corn yield from yard waste compost applications. pp. 37-41. *In* N. Eash (ed.). Proc. 1996 Southern Conservation Tillage Conference for Sustainable Agriculture. Special Publication 96-07. University of Tennessee, West Tennessee Experiment Station, Jackson, TN.

Jenkins, W.R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Dis. Report. 48:692.

McSorley, R., and R.N. Gallaher. 1995. Effect of yard waste compost on nematode densities in vegetable crops. Supplement to Journal of Nematology. 27:545-549.

McSorley, R., and R.N. Gallaher. 1996a. Effect of yard waste compost on crop tolerance to root-knot nematodes. pp. 119-123. *In* N. Eash (ed.). Proc. 1996 Southern Conservation Tillage Conference for Sustainable Agriculture. Special Publication 96-07. University of Tennessee, West Tennessee Experiment Station, Jackson, TN.

McSorley, R., and R.N. Gallaher. 1996b. Effect of yard waste compost on nematode densities and maize yield. Supplement to Journal of Nematology. 28:655-660.

McSorley, R., and R.N. Gallaher. 1997. Methods for managing nematodes in sustainable agriculture. pp. 75-79). *In* R.N. Gallaher and R. McSorley (eds.). Proc. 1997 Southern Conservation Tillage Conference for Sustainable Agriculture. Special Series SS-AGR-60, Univ. of Florida, Inst. Food & Agr. Sci., Coop. Extn. Serv., Gainesville, FL.

MSTAT 4.0. 1985. Users Guide to MSTAT, Version 4.0. Michigan State University, Lansing, MI.

Soil Survey Staff. 1994. Official soil series description for the Arredondo series. United States Government Printing Office, Washington DC.

Table 1. Silver Queen Sweet Corn Fresh Ear Weight from Old Residual and New Treatments of Yard Waste Compost (Ywc) and Three Fertilizer Treatments, Gainesville, Florida, 1998.

	Extension Fertilizer Recommendations		
Old YWC	Full	One-Half	None
	Total Fresh Ear Weight, lb/acre		
Incorporated	12230 a x	11460 a x	7140 b x
Mulch	11480 a x	10840 a x	5670 b x
Control	10880 a x	6720 b y	1750 c y

CV = 22.6%; LSD = 2234. Interaction significant at 0.05 p. Duncan's New Multiple Range Test and LSD gave same mean separation. Values among old YWC treatments within a fertilizer treatment not followed by the same letter (x, y) are significantly different at the 0.05 level of probability according to Duncan's New Multiple Range Test. Values among the extension fertilizer means within a old YWC treatment not followed by the same letter (a, b, c) are significantly different at the 0.05 level of probability according to Duncan's New Multiple Range Test.

Table 2. Bulk Density and Percent Soil Water at Water Field Capacity for the Silver Queen Sweet Corn Site from Old Residual And New Treatments of Yard Waste Compost (Ywc), Gainesville, Florida, 1998.

	New YWC		New YWC	
Old YWC	Added	Control	Added	Control
	Bulk Density, g/cc		Soil Water, %	
Incorporated	0.90 c	1.22 b*	31.9 a	22.1 a*
Mulch	1.05 b	1.23 b*	23.9 b	21.5 a NS
Control	1.40 a	1.61 a*	16.7 c	12.8 b*

Values among the three old yard waste compost treatments (YWC) within a new YWC treatment not followed by the same letter are significantly different at the 0.05 level of probability according to Duncan's New Multiple Range Test. Values between added and control of new YWC within a old YWC treatment are significantly different, as designated by a *, at the 0.05 level of probability according to LSD. LSD for bulk density = 0.07; LSD for soil water = 3.58. NS = not significant.

Table 3. Nematode Numbers Associated with Silver Queen Sweet Corn from Old Residual and New Treatments of Yard Waste Compost (Ywc) and Three Fertilizer Treatments, Gainesville, Florida, 1998.

	Nematodes			
Old YWC	Stubby-Root	Root-Knot	Lesion	Ring
	Pi - Nematodes/100 cc soil			
Incorporated	3.8 b	38.1 a	2.5 b	51.0 a
Mulch	3.1 b	29.3 a	4.8 b	21.4 a
Control	8.3 a	16.6 a	13.0 a	77.8 a
Pf - Nematodes/100 cc soil				
Incorporated	14.5 a	184.0 ab	20.8 b	424.3 ab
Mulch	13.0 a	238.0 a	18.4 b	160.0 b
Control	9.3 a	113.0 b	40.1 a	747.8 a

Values among the three old yard waste (YWC) compost treatments within a nematode species not followed by the same letter are significantly different at the 0.10 level of probability according to Duncan's New Multiple Range Test. Pi = initial populations at beginning of experiment; Pf = final populations at the end of the experiment. Stubby-Root = *Paratrichodorus minor*; Root-knot = *Meloidogyne incognita*; Lesion = *Pratylenchus* spp.; Ring = *Criconemiodes* spp.

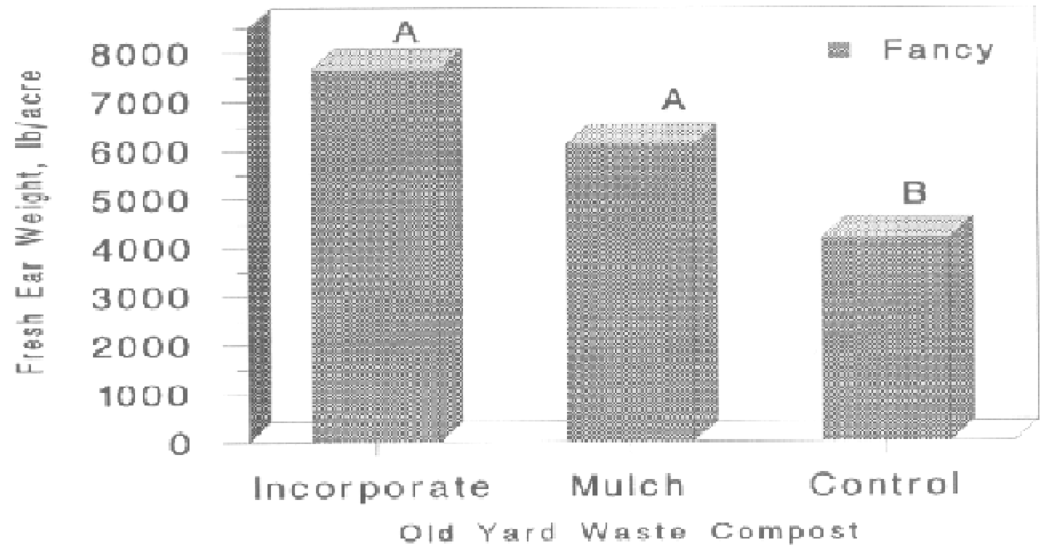
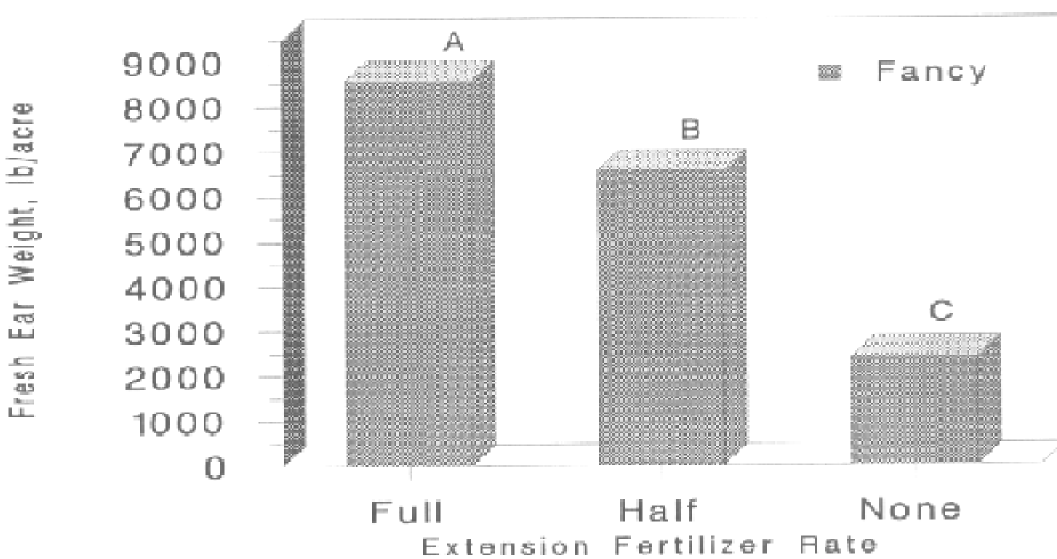


Fig. 1. 'Silver Queen' sweet corn fresh fancy grade ears for old yard waste compost (YWC) treatents averaged over new YWC and fertilizer rates. Values with the same letter are not significantly different at P=0.05.

Fig. 2. 'Silver Queen' sweet corn fresh fancy grade ears for Extension Service fertilizer rates averaged over old yard waste



compost (YWC) and new YWC. Values with the same letter are not significantly different at P=0.05.

GIBBERELLIC ACID USE IN STALE SEED BED RICE PRODUCTION

P. K. Bollich and R. T. Dunand[1]

AUTHORS: [1]Professors, Louisiana Agricultural Experiment Station, Rice Research Station, P.O. Box 1429, Crowley, LA 70527-1429; Corresponding author P.K. Bollich,; Email: pbollich@agctr.lsu.edu.

REFERENCE: J. E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*. Tifton, GA. 6-8 July 1999. Georgia. Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. Uniform emergence and adequate stand establishment are often difficult to obtainin drill-seeded rice (Oryzagativa L.)cultural systems, especially with semidwarf varieties. Gibberellic acid (GA) is a plant growth regulator that has been shown to be effective as a seed treatment in these systems and has improved both uniformity in emergence and stand density. The use of GA seed treatments is very common in conventional tillage rice systems. It is not known how effective GA is in a stale seedbed rice system, where uniform emergence and stand establishment difficulties often occur. An experiment was conducted in 1997-1998 to evaluate a GA seed treatment in a stale seedbed rice system. Two levels of seed treatment (with and without GA) and four levels of seeding rate (50, 75, 100, and 125 lb/A in 1997; 25, 50, 75, and 100 lb/A in 1998) were utilized each year. In 1997, the study was conducted on a fall-prepared stale seedbed only. In 1998, two levels of tillage (conventional tillage and fall-prepared stale seedbed) were utilized. The variety Cypress was planted into a drill-seeded and delayed flood cultural system. Emergence, stand density, days to 50% heading, plant height, grain moisture, and grain yield were determined. Emergence and final stand density were increased with both GA seed treatment and increasing seeding rate in 1997, while seeding rate and tillage method influenced stand density in 1998. Seed treatment had a small effect on stand density 8 days after planting (DAP), but final stand densities at 28 DAP were similar. Plant height and grain moisture were not affected by seeding rate or seed treatment in 1997. Seeding rate did affect plant height in 1998, and height was slightly reduced at the two higher seeding rates. Grain moisture was lower with the GA seed treatment in 1997 but not in 1998. Grain yields were significantly lower with a 50-lb/A seeding rate and no seed treatment in 1997. Grain yields of all other treatment combinations were similar. In 1998, grain yield was affected by seeding rate and tillage, while GA seed treatment had no effect. Grain yields were much lower at the 25-lb/A seeding rate, and grain yields with conventional tillage were significantly higher than those with a stale seedbed system. Gibberellic acid seed treatment appears to be effective in improving emergence and stand establishment in stale seedbed rice. Higher seeding rates in stale seedbed systems will still be required to optimize both stand densities and grain yields.

INTRODUCTION

The first semidwarf rice variety developed in the U.S. was released for commercial production in 1982. The semidwarf characteristic offered a number of advantages over conventional or tall stature rice varieties. Improved lodging resistance, higher yield potential in both the main and ratoon crops, and more response to N fertilizers have resulted in semidwarf rice varieties dominating the southern rice-growing region. While the semidwarf varieties have increased yields and profitability in rice, it was soon recognized that poor seedling vigor and emergence were typical varietal characteristics that resulted in poor stand establishment and potential yield reductions. It was first reported in Louisiana that gibberellic acid (GA), a plant growth regulator, was effective in improving emergence in semidwarf rice varieties by increasing coleoptile and mesocotyl length (Dunand, 1987). Research in Arkansas reported similar results (Helms et al., 1988).

Earlier research with GA seed treatments was confined to conventional tillage systems (Dunand, 1993). In recent years, there has been considerable interest in stale seedbed rice production, and acreage devoted to this practice continues to increase. Rice emergence and stand establishment can be difficult in stale seedbed systems as well (Bollich, 1991). Soil compaction, inadequate moisture, and preplant vegetation are factors that contribute to poor stand establishment. The use of GA to enhance emergence in stale seedbeds offers potential to offset these undesirable conditions. The objectives of this study were to (1) evaluate the use of a GA seed treatment in stale seedbed rice and (2) determine the effect of seeding rate in combination with GA on rice emergence, stand establishment, and crop production.

MATERIALS AND METHODS

A 2-year study was conducted to evaluate the effectiveness of GA seed treatment on emergence and stand establishment of rice planted into a stale seedbed. The study was conducted at the South Unit of the Rice Research Station, Crowley, LA. The soil type was a Crowley silt loam (fine, mixed, thermic Typic Albaqualfs) typical of the southwest Louisiana rice-producing region. A randomized complete block design was used, with a 2 x 4 factorial arrangement of GA levels and seeding rates in 1997 and with a 2 x 4 x 2 factorial arrangement of GA levels, seeding rates, and tillage types in 1998. Gibberellic acid levels included none and a 1-g/cwt application each year. Seeding rates included 50, 75, 100, and 125 lb/A in 1997. In 1998, seeding rates were lowered to 25, 50, 75, and 100 lb/A. The study was conducted on a fall-prepared stale seedbed in 1997, while conventional tillage and a fall-prepared stale seedbed were evaluated in 1998. The stale seedbeds were prepared in October preceding rice planting each year. Preplant vegetation in the stale seedbed was controlled with Roundup Ultra at 1.0 lb ai/A and Gramoxone Extra at 0.62 lb ai/A. Tillage in the conventional seedbed was performed just prior to planting in 1998. A complete N-P-K fertilizer (21-63-63 in 1997; 30-60-60 in 1998) was applied preplant each year. A Marliss no-till grain drill with a 7-inch drill spacing was used to seed the stale seedbed treatments. A conventional drill with similar drill spacing was used to seed the conventional treatments. The variety Cypress was planted each year. Planting depth in the stale seedbed in 1997 and 1998 was 2 in and ½ in, respectively. Planting depth in the conventional seedbed in 1998 was 1 ½ in. The experiments were flush irrigated as needed to encourage emergence and stand establishment. At the 4-leaf growth stage, urea N was applied at rates of 90 and 150 lb N/A in 1997 and 1998, respectively. A permanent flood was then established and maintained until harvest drainage 75 to 80 days later. Pest control was conducted as required according to current labeled recommendations.

In 1997, stand density was determined at 11, 13, 18, 21, and 28 days after planting (DAP). In 1998, stand density was determined at 8 and 24 days after planting. Plant height, days to 50% heading (only in 1998) grain moisture, and grain yield were determined each year. Data were statistically analyzed using Anova procedures and Duncan's Multiple Range Test was used for mean separation (Gylling and Gylling, 1983).

RESULTS

Emergence and final stand densities were increased with GA seed treatment and by increasing seeding rate in 1997 (Table 1). Emergence was very low at 11, 13, and 18 DAP, and GA seed treatment increased stand density by 50%. As seeding rate increased during the early emergence stages, stand density also increased slightly. During the later stages of emergence (21 and 28 DAP), the GA was less effective with only a 10% average increase in stand density. Final stand densities increased as seeding rate increased, but stand density with the 50 lb/A seeding rate was below the minimum 10 plants/ft^2 required for optimizing grain yield. According to current recommendations, the optimum stand density for rice is 15 to 20 plants/ft^2 (Linscombe et al., 1999). Rice can be successfully produced at slightly lower stand densities with intensive management. Seed treatment and seeding rate affected emergence and final stand densities independently, and there were no interactions between these two factors.

Mature plant height was not affected by either GA seed treatment or increasing seeding rate. Research previously conducted in conventional tillage systems indicates that GA seed treatments have only minor effects on these variables (Dunand, 1992a). An interaction occurred between GA and seeding rate for both grain moisture and grain yield. Grain moisture was significantly lower with GA at the 50-lb/A seeding rate, while grain moistures at the other seeding rates were not influenced by GA seed treatment. The higher grain moisture at the 50-lb/A seeding rate without GA seed treatment was due to the extremely low stand density. Since a uniform application of N was applied on all treatments, N was probably excessive in this treatment due to the low stand density. Grain yield was also significantly increased by GA seed treatment at the lowest seeding rate of 50 lb/A, and GA had no effect at the other seeding rates. Previous research has also shown that GA has no direct effect on grain yield, but rather indirectly influences yield by affecting stand density (Dunand, 1992b). In this instance, there was a tremendous increase in stand density with GA. Final stand density with a seeding rate of 50 lb/A and no GA seed treatment was only 2 plants/ft^2, while at the same seeding rate with GA seed treatment, the final stand density was 7 plants/ft^2.

In 1998, emergence was affected by tillage and seeding rate (Table 2). Stand densities were higher with conventional tillage, and stand densities did not change from the initial evaluation at 8 DAP to the final determination at 24 DAP. Stand densities on the stale seedbed increased 33% between 8 and 24 DAP. There was an interaction between tillage and seeding rate for initial stand densities. With conventional tillage, initial stands increased 4 plants/ft^2 with each 25-lb/A seeding rate increase. With the stale seedbed, the increase was only 2 plants/ft^2 up to the 75-lb/A seeding rate and only 1 plant/ft^2 thereafter. There was a slight effect of GA seed treatment, and initial stand density increased by an average of 10% over the control at each seeding rate, regardless of tillage. Final stand densities were affected by tillage and seeding rate independently, and there was no interaction between these two factors. With conventional tillage, final stands exceeded the minimum of 10 plants/ft^2 at all seeding rates except the lowest rate of 25 lb/A. With the stale seedbed, final stands exceeded the minimum at the 75- and 100-lb/A seeding rates. The GA seed treatment had no effect on final stand. Plant growth regulator seed treatments are generally most effective on final stand densities with planting depths of at least 1 ½ in. In the conventional tillage seedbed, there was adequate soil moisture for germination and emergence at a 1 in depth, and planting any deeper was unnecessary. In contrast, the very firm stale seedbed resulted in a much more shallow seed placement where soil moisture was inadequate for proper germination and emergence. Most of the rice in the stale seedbed did not emerge until the experiment was flushed two weeks after planting, and some of the shallow-planted seed may have lost viability during that period.

Plant stature, crop maturity, and grain yield were affected differentially by tillage and seeding rate. The GA seed treatment had no influence on any of these variables. Mature plant height was affected only by seeding rate and decreased slightly with increasing seeding rate. An interaction occurred for days to 50% heading between tillage and seeding rate. Maturity was delayed by the 25-lb/A seeding rate in the conventional seedbed only but was delayed by the 25- and 50-lb/A seeding rate in the stale seedbed. Maturity was generally delayed at the lower seeding rates as was grain moisture in 1997 and was again a function of plant population and available fertilizer N. Grain moisture was affected in the same manner as days to 50% heading. Grain moisture was higher with the stale seedbed but decreased as seeding rate increased. This response was also thought to be due to differential plant population and available fertilizer N. The differences shown in grain moisture due to tillage and seeding rate approximate a difference of 1 to 2 days.

Overall grain yields with a 25-lb/A seeding rate were significantly lower than the yields resulting from all other seeding rates. Grain yield with the 75-lb/A seeding rate was also higher than the yield resulting from the 50-lb/A seeding rate. Yields were similar with seeding rates of 75 and 100 lb/A. Grain yield was significantly higher with conventional tillage and was probably due to higher stand densities.

DISCUSSION

These results indicate that GA seed treatment can improve emergence and stand establishment in stale seedbed rice when planting deep (> 1 ½ in). These effects are magnified as seeding rate decreases below the recommended seeding rate of 90 to 110 lb/A (Saichuk et al., 1998). In contrast, there are no benefits from GA with shallow planting.

When GA seed treatment increases seedling populations above the suboptimal level (<10 plants/ft^2), yield increases are due to higher stand densities. Similar effects of stand density on grain production are produced with increases in seeding rate under both conventional and stale seedbed tillage systems, and when conventional seedbed preparation permits planting to moisture and stale seedbed preparation does not.

ACKNOWLEDGMENT

The authors express their sincere appreciation to R. Dilly, R. Regan, G.Romero, and D.M. Walker for their technical assistance and support of this research.

LITERATURE CITED

Bollich, P.K. 1991. Conservation tillage practices for rice in southwest Louisiana. Arkansas Agri. Exp. Stn. Special Report 148. Pp. 11-12.

Dunand, R.T. 1987. Plant growth regulators and U.S. rice production. Proc. Pl. Growth Reg. Soc. of Am. 14:485. Honolulu, HI. Aug 2-6.

Dunand, R.T. 1992a. Enhancement of seedling vigor in rice (Oryza sativa L.) by seed treatment with gibberellic acid. In Progress in Plant Growth Regulators. C.M. Korseen, L.C. Van Loon, and D. Vreughenhil (ed.), Kluwer Academic Publishers, Dordrecht, The Netherlands. Pp. 835-841.

Dunand, R.T. 1992b. Influence of gibberellic acid seed treatment and reduced seeding rate on semidwarf rice production. Proc. Rice Tech. Working Group. 24:122. Little Rock, AR. Feb. 23-26.

Dunand, R.T. 1993. Gibberellic acid seed treatment in rice. La. Agri. Exp. Sta. Bull. No. 842. 19 pp.Gylling, S. and F. Gylling. 1983. Pesticide research manager, Version 3.2. Gylling Data Management, Inc., Brookings, SD.

Helms, R.S., R.H. Dilday, P.B. Francis, and S.L. Skinner. 1988. Factors influencing mesocotyl and coleoptile elongation in rice. Proc. Rice Tech. Working Group. 22:40. Davis, CA. June 26-29.

Linscombe, S.L., J.K. Saichuk, K.P. Seilhan, P.K. Bollich, and E.R. Funderburg. 1999. General agronomic guidelines. In: Louisiana Rice Production Handbook. LSU Agricultural Center. Pub. 2321.

Saichuk, J., P. Bollich, D. Dautreuil, R. Dunand, E. Funderburg, D. Groth, C. Hollier, F. Jodari, R. Levy, S. Linscombe, B. Rice, D. Ring, D. Sanders, M. Stout, and L. White. 1998. Rice varieties and management tips, 1999. La. Coop. Ext. Ser. Pub. 2270. 27 pp.

Table 1. The Effects of Seeding Rate and Gibberellic Acid(GA) Seed Treatment on Seedling Vigor and Crop Production in Stale Seedbed, Drill-seeded Rice. Rice Research Station, South Unit. Crowley, La. 1997.

Seeding rate	GA rate	Stand density (DAP)[1] 11	13	18	21	28	Plant height	Grain moisture	Grain yield at 12% moisture
lb/A	g/cwt	plants/ft^2					in	%	lb/A
50	0	1	1	2	2	2	41	22.4a	4271b
75	0	2	2	4	9	8	41	20.5ab	6186a
100	0	3	3	5	10	10	42	20.2b	6976a
125	0	3	3	7	14	14	41	19.3b	6627a
50	1	2	3	4	7	7	42	20.3b	6822a
75	1	3	4	5	10	10	41	19.5b	6387a
10	1	4	4	6	11	11	42	20.3b	6423a
125	1	4	4	8	14	14	42	20.0b	6417a
C.V., %		43.84	42.02	32.29	18.66	24.71	1.31	6.47	10.38
Standard deviation		1.14	1.14	1.61	1.80	2.31	1.38	1.31	650.2
					Main effects				
GA:									
0		2a	2a	4a	9a	9a	41	20.6	6015
1		3b	3b	6b	11b	10b	42	20.0	6468
Seeding rate									
50		1a	2a	3a	5a	4a	42	21.3	5546
75		2ab	3ab	5b	9b	9b	41	20.0	6286
100		3bc	3ab	6bc	11c	10b	42	20.2	6610
125		4c	4b	7c	14d	14c	41	19.6	6522
Interaction:									
GA x seeding rate		ns	ns	ns	ns	ns	ns	*	*

[1] Means followed by the same letter do not significantly differ (Duncan's Multiple Range Test, P=0.05). Discrepancies among mean stand density values and mean separation indicators are due to rounding.

Table 2. The Effects of Seeding Rate, Ga Seed Treatment, and Tillage on Seedling Vigor and Crop Production in Drill-Seeded Rice. Rice Research Station, South Unit. Crowley, La. 1998.

Seeding rate	Tillage	Stand density (DAP)[1] 8	Stand density (DAP)[1] 24	Days to 50% heading	Plant height	Grain moisture	Grain yield at 12% moisture
lb/A		plants/ft^2			in	%	lb/A
25	Conventional	5ghi	6fg	88ab	36	20.4bcd	6736b-e
50	Conventional	11cd	11cd	84d	36	20.0cd	7261abc
75	Conventional	13c	15ab	84d	35	20.3bcd	7233abc
100	Conventional	19b	17a	83d	35	20.2cd	7296abc
25	Stale	2j	4g	90a	37	21.0b	5989fg
50	Stale	4ij	8ef	87bc	36	20.7bc	6517def
75	Stale	8d-g	13bcd	84cd	35	20.4bcd	6821b-e
100	Stale	9def	14abc	84d	36	20.0cd	7029bcd
C.V., %		21.69	18.88	2.29	1.81	2.08	5.82
Standard deviation		2.00	1.99	2.08	1.54	0.42	398.8
				Main Effects			
GA:							
0		9a	11	85	36	20.4	6860
1		10b	10	85	35	20.5	6842
Seeding rate:							
25		4	5a	88	37a	20.9a	6299a
50		7	9b	86	36ab	20.4b	6833b
75		11	13c	84	35b	20.3b	7164c
100		15	14c	83	35b	20.1b	7109bc
Tillage:							
Conventional		13	12a	84	36	20.2a	7189a
Stale		6	9b	86	36	20.6b	6513b
Interactions:							
GA x seeding rate		ns	ns	ns	ns	ns	ns
GA x tillage		ns	ns	ns	ns	ns	ns
Seeding rate x tillage		*	ns	*	ns	ns	ns
GA x seeding rate x tillage		ns	ns	ns	ns	ns	ns

[1] Means followed by the same letter do not significantly differ (Duncan's Multiple Range Test, P=0.05). Discrepancies among mean stand density values and mean separation indicators are due to rounding.

TOMATO YIELD AND SOIL QUALITY AS INFLUENCED BY TILLAGE, COVER CROPPING, AND NITROGEN FERTILIZATION

Upendra M. Sainju[1], Bharat P. Singh[2], and Sidat Yaffa[3]

AUTHORS: [1]Research Associate, [2]Professor, and [3]Research Assistant, Agricultural Research Station, Fort Valley State University, Fort Valley, GA 31030. Corresponding author Upendra M. Sainju, email: sainjuu@mail.fvsu.edu.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. Tomato yield and soil quality may be influenced by management practices and climatic conditions. We examined the effects of tillage (no-till, chisel plowing, and moldboard plowing), cover crop (hairy vetch (*Vicia villosa* Roth) and no hairy vetch), and N fertilization (0, 80, and 160 lb N acre^{-1}) on tomato yield and N uptake, root growth, and soil C and N concentrations in a Norfolk sandy loam (fine-loamy, siliceous, thermic, Typic Kandiudults) in central GA for two years. Tomato yield and N uptake were greater in moldboard or chisel than in no-till in 1996, and with hairy vetch than with no hairy vetch or with 80 or 160 than with 0 lb N acre^{-1} in 1997. In contrast, tomato total number of roots in^{-2} soil profile was greater in no-till than in moldboard in 1997and in no hairy vetch with 160 lb N acre^{-1} than in hairy vetch with 0 lb N acre^{-1}in 1996. Similarly, mineralizable C and N and organic C and N were greater in no-till or chisel than in moldboard at 0- to 4-in depth but were greater or similar in moldboard than in no-till or chisel at 4- to 12-in. Inorganic and mineralizable N were greater with hairy vetch than with no hairy vetch and with N fertilization than without. Greater rainfall increased tomato yield and N uptake in 1997. In contrast, increased temperature promoted root growth and soil C and N mineralization in 1996 better than in 1997. Instead of conventional tillage with or without cover cropping or N fertilization, chisel plowing followed by hairy vetch cover cropping and 80 lb N acre^{-1} should be adopted for improving soil and water quality and sustaining tomato yield.

INTRODUCTION

Management practices can influence crop yield and soil and water quality. While conventional tillage, such as moldboard, has sustained crop productivity, it has decreased soil quality due to increased organic matter mineralization and erosion, and water quality due to increased sedimentation and NO_3 pollution. Excessive N fertilization accompanied by poor soil and crop management practices has increased NO_3 pollution in the groundwater (Linville and Smith, 1971; Follett, 1989; Hallberg, 1989). Agriculture remains a major source of contamination, along with pollution from industrial wastes, municipal landfills, mining, and septic systems (USOTA, 1984; Hallberg, et al., 1985; USEPA, 1992). Therefore, management practices that conserve soil and nutrients are needed for improving soil and water quality and sustaining crop yield.

Tillage reduces soil quality by oxidizing organic C and N, incorporating crop residues, disrupting soil aggregates, and increasing aeration (Dalal and Mayer, 1986; Balesdent et al., 1990; Cambardella and Elliott, 1993). As a result, amendments or plant residues need to be added in the soil to replace organic matter loss by cultivation (Campbell and Souster, 1982; Collins et al., 1992; Cambardella and Elliott, 1993). Practices that reduce residue incorporation, such as no-till or minimum till, can conserve organic matter better than conventional till. Studies have shown that no-till increased organic C and N in the surface soil compared with conventional till (Doran, 1987; Havlin et al., 1990; Franzluebbers et al., 1995). Similarly, cover cropping increased soil organic C and N compared with no cover cropping (Sainju and Singh, 1997). Legume cover crops have increased crop yields and reduced N fertilizer requirements compared with non-legume or no cover crops (Sainju and Singh, 1997).

Tomato is one of the important vegetable crops in Georgia. Compared with cereal crops, vegetable crops such as tomato need intensive management and high input of N (Power and Schepers, 1989). Furthermore, recovery of N from vegetable crops is lower than from cereal crops (Lowrance and Smittle, 1988). As a result, the potentiality for NO_3 to leach from the soil is greater under vegetable than under cereal crops. Therefore, vegetables, such as tomato, need to be grown in a sustainable manner that improves soil and water quality without significantly decreasing yield. One of the ways is to use conservation tillage, followed by legume cover cropping and reduced N fertilization. Little information is available about the combined influences of tillage, cover cropping, and N fertilization on transplanted tomato and soil quality. Our objectives were to determine the effects of management practices such as tillage, cover cropping, and N fertilization, and climatic conditions such as temperature and rainfall, on (1) root and shoot growth of transplanted tomato, and (2) soil C and N concentrations.

MATERIALS AND METHODS

Field Experiment

The experiment began in September 1994 at the Agricultural Research Station farm, Fort Valley State University, Fort Valley, GA, on a Norfolk sandy loam (fine loamy, siliceous, thermic, Typic Kandiudults). The soil had 1288 ton acre^{-1} sand, 496 ton acre^{-1} silt, 198 ton acre^{-1} clay, 6.5 pH, 17.2 ton acre^{-1} organic C, and 1.3 ton acre^{-1} organic N at 0- to 12-in depth. Previous cropping history included double cropping of wheat and soybean (*Glycine max* L.) for two years followed by alfalfa (*Medicago sativa* L.) for eight years. Temperature and rainfall data were collected from a nearby weather station.

The treatments included three levels of tillage (no-till, chisel plowing, and moldboard plowing), two levels of cover crop (hairy vetch and no hairy vetch), and three levels of N fertilization (0, 80, and 160 lb N acre^{-1}). Minimum tillage (chisel plowing) consisted of harrowing (4 to 6 in depth), followed by chiseling (8 to 10 in depth) and leveling (3 to 4 in depth). Conventional tillage (moldboard plowing) consisted of harrowing, followed by moldboard plowing (8 to10 in depth) and leveling. The experiment was arranged in a strip-split plot design, with tillage and cover crop as main treatments and N fertilization as split plot treatment. Treatments were arranged in a randomized complete block with three replications. The split plot size was 24 x 24 ft.

In September and October 1994 to 1996, chisel and moldboard plots were harrowed, plowed, and leveled. No-till plots were left undisturbed except for drilling cover crop seed. Hairy vetch seed was drilled at the rate of 25 lb acre^{-1}, with a row spacing of 6 in. No fertilizer, herbicide or insecticide was applied. In March and April of the following year, hairy vetch was harvested at flowering stage from two 12 x12 in^2 areas within the plot for yield and N concentration determinations. In no hairy vetch plots, weeds (dominated by henbit (*Lamium amplexicaule* L.) and cut-leaf evening primrose (*Oenothera laciniata* L.)) were collected as above. Plant residues were oven-dried at 140°F, weighed, and ground to 0.04 in. After sampling, cover crop and weeds were mowed with a tractor-drawn mower, killed by spraying Round-Up [N-(phosphonomethyl) glycine, 3.0 lb acre^{-1}] in no-till plots, and incorporated into the soil in chisel and moldboard plots. Residues were allowed to decompose in the soil for two weeks.

In April from 1995 to 1997, P (from triple superphosphate) and K (from muriate of potash) were broadcast each at the rate of 50 lb acre^{-1}, along with 60 lb acre^{-1} of Diazinon, 5G [Diethyl 0-(2-isopropyl-6 methyl-4 pyrimidinyl) phosphorothioate] to control cutworms and 0.50 lb acre^{-1} of Treflan (2, 6-dinitrianiline) to control weeds. Chisel and moldboard plots were harrowed, plowed, and leveled. Five-week-old tomato seedlings were transplanted at a spacing of 3 ft x 3 ft. Starter solution containing 0.4 oz N, P, and K gallon^{-1} (0.36 lb acre^{-1}) was applied to each tomato plant after one week to encourage rapid establishment. Nitrogen fertilizer (nitrate of soda) was split into three doses, each broadcast at three-weeks interval from the date of transplanting. Irrigation was applied soon after fertilization in dry soil to minimize its loss and as needed.

In July 1996 and 1997, two minirhizotron acrylic tubes (2 in diam. by 36 in long) were installed 10 ft apart in the middle rows from 0 to 28 in soil depth at an angle of 15° with the vertical and 6 in away from the base of the plant (Box et al., 1989; Box, 1996). Root observations were taken at 2.5 in increment from 1 to 22.5 in depth during tomato growth using a minirhizotron camera (0.6 in by 0.5 in) attached to a rod (Bartz Technology, Santa Barbara, CA). The camera was inserted into the tube and the picture of the root in the soil profile at a particular depth was transmitted to a VCR attached to a backpack and recorded on a tape.

In July and August 1995 to 1997, tomato fruits was harvested every 3 to 4 d as the color turned from green to pink. These were picked from five plants in the two middle rows (45 ft^2 area), cut into slices, weighed, oven-dried, and ground to 0.04 in. At the final harvest in August, tomato plants were cut 1in above the ground, separated into leaves and stems, oven-dried, weighed, and ground to 0.04 in. Soil samples were collected at 0- to 4- and 4- to 12-in depths one month after cover crop incorporation in May 1996 and 1997 from five places within the two middle rows with a push tube (2 in diam.). These were composited, air-dried, and sieved to 0.08 in.

Laboratory Analysis

The N concentration in the cover crop and tomato samples was determined by the method described by Kuo et al. (1997b). The C concentration in the cover crop sample was determined by the Walkley-Black method (Nelson and Sommers, 1982), assuming that all plant C was oxidized during digestion. Nitrogen and C accumulated in the cover crop and N taken up by tomato (leaf+stem+fruit) was determined by multiplying dry matter yield by N concentration.

Nitrate and NH_4 concentrations in the soil were determined by steam distillation (Keeney and Nelson, 1982). Inorganic N concentration was determined as the sum of NH_4 and NO_3. Total N was determined by the Kjeldahl method (Bremner and Mulvaney, 1982), and organic N was determined as the difference between total and inorganic N. Organic C was determined by the Walkley-Black method. Mineralizable C and N was determined by the method described by Franzluebbers et al. (1995).

Root images recorded by minirhizotron camera were displayed in a monitor and number of roots in^{-2} soil profile area were calculated. The number of roots obtained from two tubes per plot were averaged to minimize variation within the plot and average value was used for a treatment (Hendrick and Pregitzer, 1992). Total number of roots (TNR) was calculated by adding number of roots from 1 to 22.5 in depth.

Data Analysis

Data for soil and plant parameters were analyzed statistically using the MIXED procedure of SAS (Littell et al., 1996). Sources of variation included tillage, cover crop, N fertilization, and their interactions. The least square means test was used to determine the significant difference between the means when treatment interactions were significant. Statistical significance was evaluated at *P*#0.05.

RESULTS AND DISCUSSION

Cover Crop Characteristics

Tillage and N fertilization to tomato did not influence cover crop biomass yield, N concentration, N accumulation, C accumulation, or C:N ratio (Table 1). In contrast, hairy vetch had two- to threefold greater biomass yield, one-and-a-half to twofold greater N concentration, three- to sixfold greater N accumulation and two- to fourfold greater C accumulation than weeds in the no hairy vetch treatment. The C:N ratio was lower in hairy vetch than weeds in the no hairy vetch plot. Because of higher N concentration, N accumulation in cover crop was greater in 1996 than in 1997.

Tomato Yield and Nitrogen Uptake

Tillage influenced tomato fresh fruit yield, total (stems + leaves + fruits) dry matter yield, and N uptake in 1996 (Table 2). In contrast, cover crop and tillage x N fertilization interaction influenced tomato fresh fruit and total dry yield and N uptake in 1997. Tomato fresh fruit and total dry yield were significantly greater in chisel or moldboard than in no-till, and N uptake was significantly greater in chisel than in no-till in 1996. In 1997, tomato fresh fruit and total dry yield and N uptake were greater with hairy vetch than with no hairy vetch. Similarly, tomato fresh fruit and total dry yield were greater in moldboard with 80 lb N acre^{-1} or in no-till with 160 lb N acre^{-1} than in chisel with 80 lb N acre^{-1} or in moldboard with 0 lb N acre^{-1}. Nitrogen uptake was greater in no-till with 160 lb N acre^{-1} than in chisel with 80 or 160 lb N acre^{-1} or in moldboard with 0 lb N acre^{-1}.

Lower tomato fresh fruit and total dry yield and N uptake in no-till than in chisel or moldboard in 1996 may have resulted from lower root growth at certain soil depths. In a related study, Singh and Sainju (1998) found that the number of roots in^{-2} soil profile from 7.5 to 22.5 in depth was 65% lower in no-till than in moldboard in 1996. This layer of soil may be important for plant roots to absorb moisture and nutrients, thereby influencing shoot growth. In contrast, greater tomato fresh fruit and total dry yield and N uptake with hairy vetch than with no hairy vetch in 1997 may have resulted from higher N concentration and accumulation (Table 1). Increased tomato growth with hairy vetch compared with no hairy vetch or control were obtained by several researchers (Shennan, 1992; Kelley et al., 1995; Abdul-Baki et al., 1996). Similarly, increased tomato yield with increasing N fertilization rate were reported by Garton and Widders (1990), Liptay and Nicholls (1993), and Vavrina et al. (1998).

Nitrogen recovery [(N uptake in treatment-N uptake in control)/N applied] in tomato total dry yield was 52% for N applied from hairy vetch residue in 1997. Similarly, N recovery from 80 lb N acre^{-1} was 14% and from 160 lb N acre^{-1} was 9%. In 1996, N recovery in tomato was even lower. Sweeny et al. (1987) reported that N recovered by tomato ranged from 32 to 53%. Averaged across the treatments, tomato fresh fruit and total dry yield was 6 % greater and N uptake was 22% greater in 1997 than in 1996. This may have resulted from higher rainfall in 1997 than in 1996. Total rainfall from April to August was 8.02 in greater in 1997 (24.02 in) than in 1996 (16.00 in).

Tomato Root Growth

Tomato TNR was influenced by cover crop x N fertilization interaction in 1996 and tillage in 1997 (Table 3). The TNR was significantly greater in no hairy vetch with 160 lb N acre^{-1} than in hairy vetch with 0 lb N acre^{-1} in 1996. Similarly, TNR was significantly greater in no-till than in moldboard in 1997. Averaged across the treatments, TNR was more than threefold greater in 1996 than in 1997.

Although TNR was similar between no-till and moldboard in 1996, Singh and Sainju (1998) measured 68% greater number of tomato roots from 7.5 to 22.5 in depth in moldboard than in no-till. This was because most of roots grew above 7.5 in depth, regardless of tillage. Highest concentration of roots, especially fine roots, occur near the surface soil which is rich in organic matter, nutrients, cation exchange capacity, and porosity and low in bulk density (Sainju and Good, 1993; Singh and Sainju, 1998). Fine roots constitute a large proportion of total root biomass and are important in water and nutrient absorption (Parker and Van Lear, 1996). In contrast, greater TNR in no-till than in moldboard in 1997 may have resulted from superior moisture conservation and cooler temperature in the surface soil (Merrill et al., 1996).

Greater TNR in no hairy vetch with 160 lb N acre^{-1}

than in hairy vetch with 0 lb N acre^{-1} in 1996 may have resulted from increased N availability from fertilizer N than from hairy vetch residue. This is because hairy vetch may have released N slower than N fertilizer. Legumes release N slower than N fertilizer (Ladd and Amato, 1986; Schepers and Fox, 1989). Increased tomato root growth following N fertilization were observed by several researchers (Weston and Zandstra, 1989; Widders, 1989; Garton and Widders, 1990).

Increased TNR in 1996 compared with 1997 may have resulted from increased temperature and low rainfall. The average monthly temperature in May was 6.5°F greater and in June was 4.3°F greater in 1996 than in 1997. Increased temperature to 95°F stimulates root elongation (Logsdon et al., 1987), rate of branching (Box, 1996), and dry matter biomass (Walker, 1969; Voorhees et al., 1981). Little rain in April and May 1996 was compensated by timely irrigation, thereby promoting root growth. In 1997, excessive rain that fell from June to
August may have slowed root growth.

Soil Carbon and Nitrogen

In 1996, tillage influenced mineralizable C, organic C, and organic N at 0- to 4- and 4- to 12-in depths (Table 4). Similarly, N fertilization influenced inorganic N and mineralizable N at 0- to 4- and 4- to 12-in. In 1997, tillage influenced mineralizable C, mineralizable N, and organic C at 0- to 4-in and organic N at 0- to 4-in and 4- to 12-in. Cover crop influenced inorganic N at 4- to 12-in and mineralizable N at 0- to 4- and 4- to 12-in.

Nitrogen fertilization increased inorganic N and mineralizable N compared with no N fertilization in 1996 (Table 5). Inorganic N and mineralizable N, however, were similar with 80 and 160 lb N acre^{-1} at 4- to 12-in. In 1997, mineralizable N was significantly greater in no-till than in moldboard at 0- to 4-in. Similarly, hairy vetch produced greater inorganic N at 4- to 12-in and mineralizable N at 0- to 4- and 4- to 12-in than no hairy vetch.

At 0- to 4-in, mineralizable C and organic N were greater in chisel than in moldboard and organic C was greater in no-till or chisel than in moldboard in 1996 (Table 6). In contrast, at 4- to 12-in, mineralizable C and organic C were greater in moldboard than in no-till or chisel and organic N was greater in moldboard than in no-till. Similarly, in 1997, no-till or chisel had greater mineralizable C, organic C, and organic N than moldboard at 0- to 4-in. At 4- to 12-in, moldboard had greater organic N than no-till.

Greater mineralizable C, mineralizable N, organic C, and organic N in no-till or chisel than in moldboard at 0- to 4-in may have resulted from surface placement or less incorporation of cover crop or tomato residue in the soil. When residue is placed in the surface in no-till or less incorporated into the soil in chisel than in moldboard, soil microorganisms have less contact with the residue for decomposition. As a result, C and N are conserved better at the surface soil in no-till or chisel than in moldboard (Franzluebbers et al., 1995; Havlin et al., 1990; Salinas-Garcia et al., 1997). In contrast, greater mineralizable C, organic C, and organic N in moldboard than in no-till or chisel at 4- to 12-in may have resulted from incorporation of plant residue at greater depth(Blevins et al., 1983). Increased soil organic C and N in no-till compared with conventional till at 0- to 2-in were reported by several researchers (Blevins et al., 1983; Franzluebbers et al., 1995; Havlin et al., 1990; Salinas-Garcia et al., 1997). Similarly, increased soil organic C and N in conventional till compared with no-till at 2- to 6-in was reported by Blevins et al. (1983).

Increased inorganic N and mineralizable N with hairy vetch compared with no hairy vetch in 1997 may have resulted from higher N concentration and accumulation (Table 1). Increased inorganic N and mineralizable N with legumes compared with non-legumes were observed by several investigators (Bonde and Rosswall,1987; Frankenberger and Abdelmagid, 1985; Kuo et al., 1996; Kuo and Sainju, 1998). Similarly, increased inorganic N and mineralizable N with increasing N fertilization were observed by Franzluebbers et al. (1995) and Salinas-Garcia et al. (1997).

Averaged across the treatments, inorganic N was 62% greater, mineralizable N was 43% greater, and mineralizable C was 52% greater in 1996 than in 1997. In contrast, organic C was 17% greater and organic N was 10% greater in 1997 than in 1996. This may be due to the difference in the amount of C and N added in cover crop residues and climatic conditions between 1996 and 1997. Cover crop C and N added to the soil were greater in 1996 than in 1997 (Table 1). As a result, more C and N were mineralized in 1996 than in 1997, thereby resulting in increased inorganic N, mineralizable N, and mineralizable C. Cover crops mineralize half of C and N within 2 to 9 weeks of their incorporation into the soil (Kuo et al., 1997a, b). Furthermore, increased temperature in May and June in 1996 compared with 1997 may have increased C and N mineralization, because soil organic matter mineralizes rapidly with increasing temperature to 95°F (Alexander, 1977). In contrast, decreased mineralization may have increased organic C and organic N in 1997 compared with 1996.

CONCLUSIONS

Management practices including tillage, cover cropping, and N fertilization, and climatic factors such as temperature and rainfall, influenced tomato root and shoot growth and soil organic matter (organic C and N) level. While no-till decreased tomato yield and N uptake, it promoted root growth and increased C and N concentrations in the surface soil compared with moldboard. Because of high N accumulation, hairy vetch increased soil inorganic N, mineralizable N, tomato yield, and N uptake compared with no hairy vetch. Similarly, N fertilization increased tomato yield and N uptake, root proliferation, and soil inorganic and mineralizable N compared with no N fertilization. Warmer weather in 1996 enhanced root growth and soil C and N mineralization, but higher rainfall in 1997 increased tomato yield and N uptake. Because of reduced C and N mineralization and soil erosion but similar tomato yield and N uptake compared with moldboard plowing, minimum tillage, such as chisel plowing, followed by hairy vetch cover cropping and 80 lb N acre^{-1} should be practiced for improving soil and water quality over conventional tillage and for sustaining tomato yield.

REFERENCES

Abdul-Baki, A.A., J.R. Teasdale, R. Korcak, D.J. Chitwood, and R.N. Huettel. 1996. Fresh-market tomato production in a low-input alternative system using cover crop mulch. HortScience 31:65-69.

Alexander, M. 1977. Introduction to soil microbiology. John Wiley and Sons, New York.

Balesdent, J.A., A. Mariotti, and D. Boisgontier. 1990. Effects of tillage on soil organic carbon mineralization estimated from ^{13}C abundance in maize fields. J. Soil Sci. 41:584-596.

Blevins, R.L., G.W. Thomas, M.S. Smith, W.W. Frye, and P.L. Cornelius. 1983. Changes in soil properties after 10 years of continuous non-tilled and conventionally tilled corn. Soil Tillage Res. 3:135- 136.

Bonde, T.A., and T. Rosswall. 1987. Seasonal variation of potentially mineralizable nitrogen in four cropping systems. Soil Sci. Soc. Am. J. 51:1508-1514.

Box, J.E., Jr. 1996. Modern methods of root investigation. p. 193-237. *In* Y. Waisel et al.(eds.) Plant roots: The hidden half. 2nd ed. Marcel Dekker, New York.

Box, J.E., Jr., A.J.M. Smucker, and J.T. Ritchie. 1989. Minirhizotron installation technique for investigating root response to drought and oxygen stress. Soil Sci. Soc. Am. J. 53:115-118.

Bremner, J.M., and C.S. Mulvaney. 1982. Total nitrogen. p. 595-624. *In* A.L. Page et al. (eds.) Methods of soil analysis. Part 2. Chemical and microbiological properties. 2nd ed. Agron. Monogr. 9. ASA and SSSA, Madison, WI.

Cambardella, C.A., and E.T. Elliott. 1993. Carbon and nitrogen distribution in aggregates from cultivated and native grassland soils. Soil Sci. Soc. Am. J. 57:1071-1076.

Campbell, C.A., and W. Souster. 1982. Loss of organic matter and potentially mineralizable nitrogen from Saskatchewan soils due to cropping. Can. J. Soil Sci. 62:651-656.

Collins, H.P., P.E. Rasmussen, and C.L. Douglass, Jr. 1992. Crop rotation and residue management effects on soil carbon and microbial dynamics. Soil Sci. Soc. Am. J. 56:783-788

Dalal, R.C., and R.J. Mayer. 1986. Long-term trends in fertility of soils under continuous cultivation and cereal cropping in southern Queensland. II. Total organic carbon and its rate of loss from the soil profile. Aust. J. Soil Res. 24:281- 292

Doran, J.W. 1987. Microbial biomass and mineralizable nitrogen distributions in no-tillage and plowed soils. Biol. Fertil. Soils. 5:68-75.

Follett, R.F. 1989. Nitrogen management and groundwater protection. Developments in agricultural and managed forest ecology. Vol. 21. Elsevier, New York.

Frankenberger, W.T., Jr., and H.M. Abdelmagid. 1985. Kinetic parameters of nitrogen mineralization rates of leguminous crops incorporated into soil. Plant Soil 87:257-271.

Franzluebbers, A.J., F.M. Hons, and D.A. Zuberer. 1995. Tillage and crop effects on seasonal soil carbon and nitrogen dynamics. Soil Sci. Soc. Am. J.59:1618-1624.

Garton, R.W., and I.E. Widders. 1990. Nitrogen and phosphorus preconditioning of small-plug seedlings influence processing tomato productivity. HortScience 25:655-657.

Hallberg, G.R. 1989. Nitrate in groundwater in the United States. p. 35-75. *In* R.F. Follett (ed.) Nitrogen management and groundwater protection. Developments in agricultural and managed forest ecology. Vol. 21. Elsevier, New York.

Hallberg, G.R., R.D. Libra, and B.E. Hoyer. 1985. Non-point source contamination of groundwater in Karst carbonate aquifers in Iowa. Perspectives on non-point source pollution. Proc. Natural Conf. USEPA, Washington, DC.

Havlin, J.L., D.E. Kissel, L.D. Maddux, M.M. Claasen, and J.H. Long. 1990. Crop rotation and tillage effects on soil organic carbon and nitrogen. Soil Sci. Soc. Am. J. 54:448-452.

Hendrick, R.L., and K.L. Pregitzer. 1992. Spatial variation in tree root distribution and growth associated with minirhizotrons. Plant Soil 143:283-288.

Keeney, D.R., and D.W. Nelson. 1982. Nitrogen-inorganic forms. p. 643-698. *In* A.L. Page et al. (eds.) Methods of soil analysis. Part 2. Chemical and microbiological properties. 2nd ed. Agron. Monogr. 9. ASA and SSSA, Madison, WI.

Kelley, T.C., Y.C. Lu, A.A. Abdul-Baki, and J.R. Teasdale. 1995. Economics of hairy vetch mulch systems for producing fresh market tomatoes in the Mid-Atlantic region. J. Am. Soc. Hort. Sci. 120:854-860.

Kuo, S., and U.M. Sainju. 1998. Nitrogen mineralization and availability of mixed leguminous and non-leguminous cover crop residues in soil. Biol. Fertil. Soils. 26:346- 353.

Kuo, S., U.M. Sainju, and E.J. Jellum. 1996. Winter cover cropping influence on nitrogen mineralization, presidedress soil nitrate test, and corn yields. Biol. Fertl. Soils. 22:310- 317.

Kuo, S., U.M. Sainju, and E.J. Jellum. 1997a. Winter cover crop effects on soil organic carbon and carbohydrate. Soil Sci. Soc. Am. J. 61:1

Kuo, S., U.M. Sainju, and E.J. Jellum. 1997b. Winter cover cropping influence on nitrogen in soil. Soil Sci. Soc. Am. J.61:1392-1399.

Ladd, J.N., and M. Amato. 1986. The fate of nitrogen from legume and fertilizer sources in soils successively cropped with wheat under field conditions. Soil Biol. Biochem. 18:417-425.

Linville, K.W., and G.E. Smith. 1971. Nitrate content of soil cores from corn plots after repeated nitrogen fertilizations. Soil Sci. 112:249-255.

Liptay, A., and S. Nicholls. 1993. Nitrogen supply during greenhouse transplant production affects subsequent tomato root growth in the field. J. Am. Soc. Hort. Sci. 118:339-342.

Littell, R.C., G.A. Milliken, W.W. Stroup, and R.D. Wolfinger. 1996. SAS system for mixed models. SAS Inst., Cary, NC

Logsdon, S.D., R.B. Reneau, Jr., and J.C. Parkers 1987. Corn seedling root growth as influenced by soil physical properties. Agron. J. 79:221- 224.

Lowrance, R., and D. Smittle. 1988. Nitrogen cycling in a multiple crop-vegetable production system. J. Environ. Qual. 17:158-162.

Merrill, S.D., A.L. Black, and A. Bauer. 1996. Conservation tillage affects root growth of dryland spring wheat under drought. Soil Sci. Soc. Am. J. 60:575-583.

Nelson, D.W. , and L.E. Sommers. 1982. Total carbon, organic carbon, and organic matter. p. 539-579. *In* A.L. Page et al. (eds.) Methods of soil analysis. Part 2. Agron. Monogr. 9. ASA and SSSA, Madison, WI.

Parker, M.M., and D.H. Van Lear. 1996. Soil heterogeneity and root distribution of mature loblolly pine stands in Piedmont soils. Soil Sci. Soc. Am. J. 60:1920-1925.

Power, J.F., and J.S. Schepers. 1989. Nitrate contamination of groundwater in North America. Agric. Ecosyst. Environ. 26:165-187.

Sainju, U.M., and R.E. Good. 1993. Vertical root distribution in relation to soil properties in New Jersey Pinelands forests. Plant Soil 150:87-97.

Sainju, U.M., and B.P. Singh. 1997. Winter cover crops for sustainable agricultural systems: Influence on soil properties, water quality, and crop yields. HortScience 32:21-28.

Salinas-Garcia, J.R., F.M. Hons, and J.E. Matocha. 1997. Long-term effects of tillage and fertilization on soil organic matter dynamics. Soil Sci. Soc. Am. J. 61:152-159.

Schepers, J.S., and R.H. Fox. 1989. Estimation of nitrogen budgets for crops. p. 221-246. *In* R.F. Follett (ed.) Nitrogen management and groundwater protection. Vol. 21. Elsevier, Amsterdam.

Shennan, C. 1992. Cover crops, nitrogen cycling, and soil properties in semi-irrigated vegetable production systems. HortScience 27:749-754.

Singh, B.P., and U.M. Sainju. 1998. Soil physical and morphological properties and root growth. HortScience 33:966-971.

Sweeney, D.W., D.A. Greatz, A.B. Bottcher, S.J. Locaccio, and K.L. Campbell. 1987. Tomato yield and nitrogen recovery as influenced by irrigation method, nitrogen source, and mulch. HortScience 22:27-29.

United States Environmental Protection Agency (USEPA). 1992. Annual needs survey. USEPA, Office of Water, Washington, DC.

United States Office of Technology Assessment (USOTA). 1984. Protecting the national groundwater from contamination. USOTA, Washington, D.C.

Vavrina, C.S., G.J. Hochmuth, J.A. Cornell, and S.M. Olson. 1998. Nitrogen fertilization of Florida grown tomato transplants: Seasonal variation in greenhouse and field performance. HortScience 33:251-254.

Viets, F.G. 1965. The plant's need for and use of nitrogen. p. 503-549. *In* W.V. Bartholomew and F.E. Clark (eds.) Soil nitrogen. Agron. Monogr. No. 10. ASA and SSSA, Madison, WI.

Voorhees, W.B., R.R. Allmaras, and C.E. Johnson. 1981. Alleviating temperature stress. p. 217-266. *In* G.F. Arkin and H .M. Taylor (eds.) Modifying the root environment to reduce crop stress. Monogr. No. 4. ASAE, St. Joseph, MI.

Walker, J.M. 1969. One-degree increment in soil temperature affects maize seedling behavior. Soil Sci. Soc. Am. Proc. 33:729-736.

Weston, L.A., and B.H. Zandstra. 1989. Transplant age and N and P nutrition effects on growth and yield of tomatoes. HortScience 24:88-90.

Widders, I.E. 1989. Pretransplant treatments of N and P influence growth and elemental accumulation in tomato seedlings. J. Am. Soc. Hort. Sci. 114:416-420.

Table 1. Biomass yield, N concentration, N accumulation, C accumulation, and C:N ratio of cover crops.

	Biomass Yield		N concentration		N accumulation		C accumulation		C:N ratio	
Cover Crop	1996	1997	1996	1997	1996	1997	1996	1997	1996	1997
	-----ton acre^{-1}-----		---------%---------		--------------------lb acre^{-1}-----------					
Hairy vetch	2.44aH	1.86a	0.38a	0.19a	184a	69a	2153a	1628a	11.7a	23.6a
No hairy vetch (weeds)	0.87b	0.85b	0.19b	0.14b	33b	24b	594b	775b	18.0b	32.3b

H Within a column, numbers followed by the same letter are not significantly different at *P*#0.05 by the least square means test.
*, **, and *** Significant at *P*#0.05, 0.01, and 0.001, respectively; NS, not significant.

Table 2. Tomato Yield and N Uptake as Influenced by Tillage, Cover Cropping, and N Fertilization.

Treatment	N Rate	Fresh fruit yield		Total (stem + leaves + fruits) dry yields		N Uptake	
		1996	1997	1996	1997	1996	1997
	lb ac^{-1}	ton acre^{-1}		ton acre^{-1}		lb acre^{-1}	
Tillage							
No-till		15.6b	----	1.22b	----	62.1b	----
Chisel		29.6 a	----	1.66 a	----	96.0 a	----
Moldboard		28.1 a	----	1.58 a	----	90.7 ab	----
Cover crop							
Hairy vetch		----	28.1 a	----	1.74 a	----	112.7 a
No hairy vetch		----	22.9 b	----	1.42 b	----	89.3 b
Tillage x N fertilization							
No-till	0	----	23.7 ab	----	1.47 ab	----	93.5 ab
	80	----	26.0 ab	----	1.61 ab	----	101.3 ab
	160	----	29.2 a	----	1.81 a	----	119.9 a
Chisel	0	----	24.0 ab	----	1.49 ab	----	99.4 ab
	80	----	22.4 b	----	1.39 b	----	87.9 b
	160	----	23.1 ab	----	1.43 ab	----	95.1 b
Moldborad	0	----	22.6 b	----	1.40 b	----	87.5 b
	80	----	30.5 a	----	1.89 a	----	117.3 ab
	160	----	28.1 ab	----	1.74 ab	----	106.6 ab
Significance							
Tillage (Till)		*	NS	*	NS	*	NS
Cover crop (Crop)		NS	*	NS	*	NS	NS
Till x Crop		NS	NS	NS	NS	NS	NS
N Fertilization(Fert)		NS	*	NS	*	NS	*
Till x Fert		NS	*	NS	*	NS	*
Crop x Fert		NS	NS	NS	NS	NS	NS
Till x Crop x Fert		NS	NS	NS	NS	NS	NS

Ħ Within a column of a treatment, numbers followed by the same letter are not significantly different at $P \leq 0.05$ by the least square means test.
* Significant at $P \leq 0.05$; NS, not significant.

Table 3. Tomato total number of roots from 1 to 22.5 in soil depth measured by minirhizotron method as influenced by tillage, cover cropping, and N fertilization.

Treatment	N rate	1996	1997
	lb ac^{-1}	no. roots in^{-2} soil profile	
		Tillage	
No-Till		102.9 a H	40.1 a
Moldboard		111.3 a	17.4 b
		Cover crop x N fertilization (lb $acre^{-1}$)	
Hairy vetch	0	89.7 b	28.6 a
	180	108.6 ab	26.5 a
No hairy vetch	0	130.2 a	37.9 a
	180	99.8 ab	22.1 a
		Significance	
Tillage (Till)		NS	*
Cover crop (Crop)		NS	NS
Till x Crop		NS	NS
N fertilization (Fert)		NS	NS
Till x Fert		NS	NS
Crop x Fert		0	NS
Till x Crop x Fert		NS	NS

H Within a column of a treatment, numbers followed by the same letter are not significantly different at *P*#0.05 by the least square means test. * Significant at *P*#0.05; NS, not significant.

Table 4. Analysis of variance for soil C and N under tomato.

Sources	Inorganic N		Mineralizable C		Mineralizable N		Organic C		Organic N	
Depth (in.)H	0-4	4 -12	0-4	4 -12	0-4	4 -12	0-4	4 -12	0-4	4 -12
					1996					
Tillage(Till)	NS	NS	NS	*	NS	NS	*	*	*	NS
Cover Crop (Ccrop)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Till x Ccrop	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N Fertilization (Fert)	***	*	NS	NS	***	*	NS	NS	NS	NS
Till x Fert	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ccrop x Fert	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Till x Ccrop x Fert	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
					1997					
Tillage(Till)	NS	NS	**	NS	*	NS	*	NS	*	NS
Cover Crop (Ccrop)	NS	*	NS	NS	*	*	NS	NS	NS	NS
Till x Ccrop	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N Fertilization (Fert)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Till x Fert	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ccrop x Fert	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Till x Ccrop x Fert	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

H 0 to 4 in soil depth; 4 to 12 in soil depth. *, **, and *** Significant at *P*#0.05, 0.01, and 0.001, respectively; NS, not significant.

Table 5. Soil Inorganic and Mineralizable N under Tomato as Influenced by Tillage, Cover Cropping, and N Fertilization.

Treatment	Inorganic N		Mineralizable N	
Depth (in.) H	0-4	4-12	0-4	4-12
	-- lb acre^{-1}	--		
		1996		
		N fertilization (lb acre^{-1})		
0	30.2c'	67.3 b	41.2 b	87.6 b
80	37.6 b	87.6 a	46.2 b	110.1 a
160	46.9 a	77.6 ab	60.3 a	102.2 ab
		1997		
		Tillage		
No-till	22.5 a	56.5 a	38.8 a	80.5 a
Chisel	19.3 a	49.9 a	33.2 ab	69.4 a
Moldboard	16.4 a	49.6 a	26.5 b	64.2 a
		Cover Crop		
Heavy vetch	23.1 a	70.2 a	39.1 a	88.7 a
No hairy vetch	15.5 a	33.8 b	26.6 b	53.9 b

H 0 to 4 in soil depth; 4 to 12 in soil depth. ' Within a column of a treatment, numbers followed by the same letter are not significantly different at *P*#0.05 by the least square means test.

Table 6. Soil mineralizable C, organic C, and organic N under tomato as influenced by tillage.

Tillage	Mineralizable C		Organic C		Organic N	
Depth (in.)H	0-4	4-12	0-4	4-12	0-4	4-12
	---------lb acre^{-1}---------		--------ton acre^{-1}------		--------ton acre^{-1}--------	
			1996			
No-till	202.4ab'	301.8b	8.50a	14.65b	0.40ab	0.70b
Chisel	205.2a	325.2b	8.85a	14.12b	0.46a	0.74ab
Moldboard	168.8 b	414.5 a	7.03 b	17.69 a	0.34 b	0.85 a
			1997			
No-till	151.7a	195.4a	10.3a	20.46 a	0.49a	0.92 a
Chisel	156.7 a	257.4 a	9.07 a	17.95 a	0.44 a	0.86 ab
Moldboard	76.5 b	223.9 a	7.59 b	17.56a	0.33 b	0.77b

H 0 to 4 in soil depth; I 4 to 12 in soil depth. ' Within a column of a treatment, numbers followed by the same letter are not significantly different at *P*#0.05 by the least square means test.

NEMATODE POPULATIONS ON ROUNDUP-READY COTTON IN FLORIDA

R. McSorley[1] and R. N. Gallaher[2]

AUTHORS: [1]Entomology and Nematology Department and [2]Agronomy Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL. [1]P.O. Box 110620, University of Florida, Gainesville, FL 32611-0620; Email: rmcs@gnv.ifas.ufl.edu .
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22[nd] Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. Population densities of plant-parasitic nematodes were compared on cotton (*Gossypium hirsutum*) varieties in three experiments in north central Florida. In one experiment conducted in 1997, buildup of nematode populations was similar on cotton varieties tolerant to Roundup and varieties that are intolerant. The effects of tillage and cotton variety on nematode populations were examined in the other two experiments. Tillage rarely affected nematode populations, and the effects of cotton variety on nematodes were infrequent and inconsistent. It is concluded that nematode buildup on the Roundup-tolerant and Roundup-intolerant cotton varieties tested was similar. Increase of the root-knot nematode, *Meloidogyne incognita* race 1, during the course of a cotton crop was attributed to the presence of weed hosts, particularly late in the season. In general, lesion (*Pratylenchus* spp.) and dagger (*Xiphinema* spp.) nematodes increased on cotton, while populations of ring (*Criconemella* spp.) and stubby-root (*Paratrichodorus minor*) declined on the crop.

INTRODUCTION

Plant-parasitic nematodes are important pests of cotton (*Gossypium hirsutum*) and other commercial crops. In the southern United States, the most damaging nematodes on cotton are race 3 of the root-knot nematode (*Meloidogyne incognita*) and the reniform nematode (*Rotylenchulus reniformis)* (Starr and Page, 1990).

As cotton acreage increases in Florida, so has the concern with nematode pests and their management (Kinloch and Sprenkel, 1994; Rich et al., 1997). A survey conducted in north Florida in 1990 found root-knot nematodes in 61% of the fields sampled and reniform nematodes in 15% of Florida fields (Kinloch and Sprenkel, 1994). As cotton production expanded into northeast Florida, damage by the sting nematode (*Belonolaimus longicaudatus*) has been observed (Crow et al., 1997; 1998). Since cotton is susceptible to race 3 but not to race 1 of *M. incognita* (Taylor and Sasser, 1978), cotton has been used successfully as a rotation crop in north central Florida in sites where race 1 of *M. incognita* predominates (McSorley and Dickson, 1995).

Roundup-tolerant or "Roundup-ready" cotton varieties can be useful in conservation tillage programs (Brecke, 1997), and so interest in these varieties is increasing. The objective of this research is to determine the nematodes associated with Roundup-ready cotton in north central Florida. Information will be provided on which plant-parasitic nematodes build up on cotton in this part of the state, and on Roundup-ready varieties in particular.

MATERIALS AND METHODS

Three separate experiments were conducted on an Arredondo fine sand (94% sand, 3.5% silt, 2.5% clay) at the University of Florida Green Acres Agronomy Research Farm in Alachua County during 1997 and 1998.

Experiment 1 - - Cotton Varieties, 1997

This experiment consisted of four cotton varieties (Stoneville ST 474, Deltapine NUCOTN 33B, Deltapine DP 5690 RR, Deltapine DP 5415 RR) replicated six times in a randomized complete block design. The suffix "RR" designates a Roundup-ready variety. This experiment followed a winter cover crop of 'Tift Blue' lupin (*Lupinus angustifolius*).

The experimental site was mowed on 25 April 1997 and plots were established with a Brown-Hardin strip-till planter. The area was sprayed with 2 quarts Roundup/acre on 2 May and cotton was strip-till planted on 8 May. Rows were 30 inches wide and 20 feet long and there were four rows per plot. On 9 May, preemergence application of 0.75 lb a.i. Prowl and 1.00 lb a.i. Meturon 4L/acre was made. A 13-5-29-1-2.5 (N-P_2O_5-K_2O-Mg-S) fertilizer was applied at 475 lb/acre on 13 June. An additional 250 lb/acre of the same fertilizer mixture was sidedressed on 8 August and an additional 75 lb N/acre was sidedressed on 13 August. Over-top application of 1.5 pints/acre of Roundup was sprayed over the two Roundup-ready varieties of cotton on 16 June. The two non Roundup-ready varieties were post-direct sprayed with 1.5 pints Gramoxone on 30 June. Insects were controlled by use of 1.5 pints Lannate/acre on 23 June, 30 July, and 18 August. Hand harvesting of the middle two rows of cotton began on 15 September and was completed on 2 October. Soil samples for nematode analysis were collected on 19 November 1997, as described below.

Experiment 2 - - Tillage and Cotton Varieties, 1997

This was a split-plot experiment with four tillage treatments as main plots and three cotton varieties as subplots. All treatment combinations were replicated four times. Individual subplots consisted of four rows, 15 ft long, with 2.5 ft between rows. The four tillage treatments were: no tillage, with and without subsoiling, and conventional tillage, with and without subsoiling. The three cotton varieties used in 1997 were Deltapine DP 5690 RR, Deltapine DP 5415 RR, and Stoneville ST 474.

A winter cover crop of 'Wrens Abruzzi' rye (*Secale cereale*) was mowed on 10 April 1997 to 1-ft height. Conventional tillage plots were removed close to the ground on 29 April and tilled two times with a rototiller to a depth of 6 to 8 inches. Two qt of Roundup/acre were applied over no-till plots on 2 May. Cotton was planted on 7 May at a rate of 110 seeds per 20 ft of row. A preemergence application of 0.75 lb a.i. Prowl and 1.00 lb a.i. Meturon 4L per acre was made on 9 May. An over-the-top application of 1.5 pt Roundup was applied to the Roundup-ready varieties on 13 June, and the non-Roundup-ready variety (Stoneville ST 474) was mechanically cultivated the same day. A post-direct application of 1.5 pt Gramoxone/acre was made on all cotton on 30 June. Additional hand-weeding of the plots with 'Stoneville ST 474' was necessary on 6 October. A broadcast application of 460 lb/acre of 13-5-29-1-2.5 (N-P_2O_5-K_2O-Mg-S) was applied on 14 May. Sidedress applications of 115 lb/acre of ammonium nitrate were made on 12 June and 26 June. Insects were controlled by applications of 1.5 pt Lannate/acre on 23 June, 30 July, and 18 August. An application of 2 pt Gramoxone/acre was sprayed over the top of the cotton on 12 September as a harvest aid. The middle two rows of each subplot were harvested by hand beginning on 6 October and ending on 22 October. Soil samples for nematode analysis were collected from each subplot on 9 May and 24 September 1997.

Experiment 3 - - Tillage and Cotton Varieties, 1998

The experimental design, fertilizer rates, and crop management practices used in this experiment were similar to those used in Experiment 2. However, the cotton variety Deltapine DP 655 BG/RR was substituted for 'Stoneville ST 474' in 1998. Therefore all cotton varieties used in Experiment 3 were Roundup-ready varieties, and so the weed management protocol for Roundup-ready cotton (see Experiment 2 above) was used for all cotton in this season. Cotton was planted on 15 May and was harvested from 30 October to 13 November. Soil samples for nematode analysis were collected on 28 May and 8 December 1998.

Nematode Samples

Each sample consisted of six soil cores (1 in. diameter and 8 in. deep) collected in a systematic pattern from the center two rows of each subplot. The cores comprising each sample were mixed together, and in the laboratory, a 100-cc soil subsample was removed for nematode extraction using a modified sieving and centrigation procedure (Jenkins, 1964). Extracted nematodes were identified and counted under an inverted microscope. All data were analyzed by an analysis of variance for a split-plot design (Freed et al., 1991), followed by mean separation by Duncan's multiple-range test if appropriate.

RESULTS

Experiment 1 - - Cotton Varieties, 1997

Nematodes found following cotton at this site included ring (*Criconemella* spp.), root-knot (*Meloidogyne incognita* race 1), stubby-root (*Paratrichodorus minor*), lesion (*Pratylenchus* spp.), and dagger nematodes (*Xiphinema* spp.). No differences in numbers of any of these nematodes among the various cotton varieties were observed (Table 1).

Experiments 2 and 3 - - Tillage and Cotton Varities

The same plant-parasitic nematodes found in Experiment 1 also occurred in this site. Nematode numbers shortly after planting and late in each season are shown (Tables 2, 3). However, relatively few significant (P#0.10) effects from cotton variety were observed, and these were inconsistent from year to year (table 4). No significant (at P#0.10) tillage x variety interaction was obtained for any nematode. A significant (P#0.10) tillage effect was obtained for lesion nematodes on 8 December 1998. On that date, significantly (P#0.10) more lesion nematodes were recovered from no-till plots (mean = 31.9 nematodes/100 cc soil) than from the no-till + subsoil plots (15.5/100 cc), the conventional till + subsoil plots (18.7/100 cc), or the conventional till plots (13.6/100 cc).

DISCUSSION

Based on the experiments in which Roundup-ready varieties and nontolerant varieties were compared directly (Experiments 1, 2), it appears that in general, similar numbers of plant-parasitic nematodes built up on Roundup-tolerant and non-tolerant varieties. The greatest difference observed was in the buildup of more dagger nematodes on 'Stoneville ST 474' than on 'Deltapine DP 5690 RR' (Tables 2, 4).

These experiments also provide information on the plant-parasitic nematodes which built up on cotton in north central Florida. Although ring and stubby-root nematodes occurred on cotton at this site, their population levels declined during the cotton crop in both years (Tables 2, 3). On the other hand, root-knot and lesion nematodes increased during the cotton crop in both years, since their numbers at the end of the season were generally greater than their numbers in samples collected near planting time (Tables 2, 3). In 1997, moderate numbers of dagger nematodes were recovered following the cotton crop, even though their numbers were below detectable levels at planting (Table 2).

The buildup of *M. incognita* on the cotton crop was unexpected, since the *M. incognita* population found in this site was race 1. Cotton is a host to race 3 of *M. incognita* but not to race 1 (Taylor and Sasser, 1978). The presence and increase of *M. incognita* in this field is attributed to weeds which persisted despite the herbicide program used on the cotton crops. Weed hosts of root-knot nematodes which were common in this site late in each season included morningglory (*Ipomoea* spp.) and beggarweed (*Desmodium tortuosum*).Root-knot nematode populations were higher in 1998, when nematode samples were collected after cotton harvest and additional weed growth had occured, than in 1997, when nematode samples were collected before cotton harvest began. No galling from root-knot nematodes was observed on the roots of cotton plants in either season.

It is encouraging that the major nematode pests of cotton - - *M. incognita* race 3, *R. reniformis*, and *B. longicaudatus* - - did not build up on cotton in this location in north central Florida. However, the cultivation of cotton in this area is very recent, and when the crop is grown more often, particularly in the same field, there is increased likelihood that nematode pests characteristic of this crop may build up. *Belonolaimus longicaudatus* is common in the vicinity (Crow et al., 1998; McSorley and Dickson, 1995), although it was not found in this study.

SUMMARY

The use of cotton varieties tolerant to the herbicide Roundup is increasing in the southern United States. However, as the use of new varieties increases, so does the potential for buildup of pest problems characteristic of those varieties. Three experiments were conducted in north central Florida during 1997 and 1998 to examine the buildup of plant-parasitic nematodes on Roundup-ready cotton varieties. In general, the buildup of plant-parasitic nematodes on Roundup-tolerant and Roundup-intolerant cotton varieties was similar. The various kinds of nematodes which occurred in these cotton crops are discussed in detail.

LITERATURE CITED

Brecke, B. J. 1997. Weed management in no-till Roundup tolerant soybean and cotton. p.233-237. In R. N.

Gallaher and R. McSorley (eds.). Proceedings of the 20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Special Series SS-AGR- 60, University of Florida, Gainesville, FL.

Crow, W. T., D. W. Dickson, and D. P. Weingartner. 1997. Stubby-root symptoms on cotton induced by *Belonolaimus longicaudatus*. J. Nematol. 29:574 (abstr.).

Crow, W. T., D. P. Weingartner, and D. W. Dickson. 1998. Reduction in root growth and yield of cotton induced by *Belonolaimus longicaudatus*. Phytopathology 88:S19 (abstr.).

Freed, R., S. P. Eisensmith, S. Goetz, D. Reicosky, V. W. Smail, and P. Wolberg. 1991. User's guide to MSTAT-C. Michigan State University, East Lansing, MI.

Jenkins, W. R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Dis. Reptr. 48:692.

Kinloch, R. A., and R. K. Sprenkel. 1994. Plant- parasitic nematodes associated with cotton in Florida. Suppl. J. Nematol. 26:749-752.

McSorley, R., and D. W. Dickson. 1995. Effect of tropical rotation crops on *Meloidogyne incognita* and other plant-parasitic nematodes. Suppl. J. Nematol. 27:535-544.

Rich, J. R., S. K. Barber, R. A. Kinloch, and D. L. Wright. 1997. Management of reniform nematodes in strip till cotton treated with Temik 15G and Telone II, including use of Telone II at planting. p. 223-226. In R. N. Gallaher and R. McSorley (eds.). Proceedings of the 20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Special Series SS-AGR-60, University of Florida, Gainesville, FL.

Starr, J. L., and S. L. J. Page. 1990. Nematode parasites of cotton and other tropical fibre crops. p. 539-556. In M. Luc., R. A. Sikora, and J. Bridge (eds.) Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. CAB International, Wallingford, U.K.

Taylor, A. L., and J. N. Sasser. 1978. Biology, identification and control of root-knot nematodes (*Meloidogyne*spices North Carolina State University Graphics, Raleigh, NC.

Table 1. Plant-parasitic Nematode Population Densities Following Four Cotton Varieties, Experiment 1, 19 November 1997.

Cotton variety	Nematode				
	Ring	Root-knot	Stubby-root	Lesion	Dagger
	Nematodes per 100 cc soil				
Stoneville ST 474	86.8	0.2	21.0	25.2	2.0
Deltapine NUCOTN 33B	62.3	7.5	15.8	33.5	3.7
Deltapine DP 5690 RR	99.8	1.8	15.3	18.0	2.5
Deltapine DP 5415 RR	73.8	0.7	15.5	25.7	2.3

Data are means of six replications. No significant differences (P#0.10) in nematode numbers among cotton varieties.

Table 2. Effect of Tillage and Cotton Variety on Population Densities of Plant-parasitic Nematodes, Experiment 2, 1997.

Tillage treatment	Cotton Variety	Ring	Root-knot	Stubby-root	Lesion	Dagger
		Nematodes per 100 cc soil				
		9 May 1997				
NT+sub	–	184.0	7.0	8.5	8.5	0
NT	–	81.0	5.8	16.0	11.8	0
CT+sub	–	174.8	3.0	12.2	2.5	0
CT	–	231.8	11.5	5.5	6.5	0
		24 September 1997				
NT+sub	Deltapine DP 5690 RR	61.5	0	1.0	9.2	1.5
	Deltapine DP 5415 RR	17.2	21.8	0.2	10.2	5.7
	Stoneville ST 474	25.8	36.8	0	3.0	23.2
NT	Deltapine DP 5690 RR	23.5	3.2	0.8	11.0	1.0
	Deltapine DP 5415 RR	56.5	0.2	0.8	13.8	9.5
	Stoneville ST 474	28.2	12.8	0	5.2	21.8
CT+sub	Deltapine DP 5690 RR	25.0	12.8	1.5	7.8	1.8
	Deltapine Dp 5415 RR	29.8	12.2	0.5	19.0	0.8
	Stoneville ST 474	19.0	8.5	0.2	6.2	11.0
CT	Deltapine DP 5690 RR	11.5	11.2	1.8	8.2	0
	Deltapine DP 5415 RR	107.5	35.2	2.0	15.5	0.5
	Stoneville ST 474	18.0	2.5	0.2	6.0	0.8

[1]NT + sub = no-till with subsoil; NT = no-till; CT + sub = conventional till with subsoil; CT = conventional till. Data are means of four replications.

Table 3. Effect of Tillage and Cotton Variety on Population Densities of Plant-parasitic Nematodes,Experiment 3, 1998.

Tillage Treatment	Cotton Variety	Ring	Root-knot	Stubby-root	Lesion	Dagger
				Nematodes per 100 cc Soil		
			28 May 1998			
NT+sub	–	257.5	0.2	36.2	24.5	0
NT	–	93.5	4.0	37.2	8.8	2.8
CT+sub	–	154.8	1.8	58.2	13.0	0
CT	–	199.2	0	77.0	19.2	0
			8 December 1998			
NT+sub	Deltapine DP 5690 RR	3.0	29.2	2.0	14.2	0
	Deltapine DP 5415 RR	26.2	60.5	4.0	13.0	0.5
	Deltapine DP 655 BG/RR	66.2	9.2	5.0	19.2	0
NT	Deltapine DP 5690 RR	38.2	36.0	2.8	29.5	0
	Deltapine DP 5415 RR	74.2	8.8	6.5	33.8	0
	Deltapine DP 655 BG/RR	31.8	60.2	9.0	32.5	0.5
CT + sub	Deltapine DP 5690 RR	10.8	9.8	1.5	20.8	0
	Deltapine DP 5415 RR	32.0	86.0	22.0	21.0	0
	Deltapine DP 655 BG/RR	103.0	13.0	1.0	14.2	0
CT	Deltapine DP 5690 RR	17.0	91.0	1.2	13.0	0
	Deltapine DP 5415 RR	41.8	22.0	1.0	15.0	0
	Deltapine DP 655 BG/RR	95.0	7.0	3.0	12.8	0.8

[1]NT + sub = no-till with subsoil; NT = no-till; CT + sub = conventional till with subsoil; CT = conventional till. Data are means of four replications.

Table 4. Summary of Significant Effects of Cotton Varieties on Plant-parasitic Nematode Populations, 1997 and 1998.

Cotton Variety	Ring	Stubby-root	Lesion	Dagger
		Nematodes per 100 cc soil		
		24 September 1997		
Deltapine DP 5690 RR	–	1.2 a[1]	9.0 b	1.1 b
Deltapine DP 5415 RR	–	0.9 ab	14.6	4.1 ab
Stoneville ST 474	–	0.1 b	5.1 c	14.2 a
		8 December 1998		
Deltapine DP 5690 RR	17.2 b[1]	- -	- -	- -
Deltapine DP 5415 RR	43.6 ab	- -	- -	- -
Deltapine DP 655 BG/RR	74.0 a	- -	- -	- -

Data are subplot (variety) means, across tillage treatments. Means in columns followed by the same letter do not differ at P#0.05, according to Duncan's multiple-range test. Dashes (-) indicate subplot (variety) effect not significant at P#0.10.

[1]Mean separation based on P#0.10.

INFLUENCE OF NITROGEN LEVELS ON COTTON PLANT/INSECT INTERACTIONS IN A CONSERVATION TILLAGE SYSTEM

D. M. Olson[1], S. C. Phatak[2] & W. J. Lewis[1]

AUTHORS: [1]USDA-ARS, Insect Biology & Population Management Research Laboratory, P. O. Box 748, Tifton, GA 31794, [2]University of Georgia, Dept. of Horticulture, 100 Horticulture, Coastal Plain Experiment Station, Tifton, GA 31794. Corresponding author: D. M. Olson, Email: dolson@tifton.cpes.peachnet.edu

REFERENCE: J. E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. Plants have indirect defenses against herbivores through the attraction of the third trophic level to damaged plants that have been induced to produce and emit volatile chemical signals. These defenses can increase plant fitness, but recent studies indicate that nitrogen levels can effect a plant's ability to produce them. This study tests the effects of various nitrogen levels in a cotton field conservation tilled with plants previously damaged by *Spodoptera exigua* on the abundance of insect species, fruit production and damage, and total plant yield. Nitrogen was applied at 0, 30, 60 & 120 lb/acre in a conservation-tilled cotton field planted with a winter cover crop of Crimson clover, with 10 plants per plot damaged by *S. exigua* larvae. Whole plants were sampled twice during the season. There was a general pattern of increasing numbers of *Helicoverpa zea* and *Heliothis virescens* eggs and larvae, and lacewing eggs, larvae and pupae with increasing nitrogen, and previous plant damage had an effect on the number of eggs, larvae and pupae only at high nitrogen levels. Total fruit production and damage was highest in the plots with the highest nitrogen, but fruit production and damage was not influenced by previous plant damage by *S. exigua*. Yields across all nitrogen levels were not significantly different. The oviposition preference of insects on previously damaged plants at high nitrogen levels, may indicate that plant signals have been altered by nitrogen rates in such a manner that the pest perceives a weakened plant and the predator perceives higher numbers of prey.

INTRODUCTION

A total system approach to pest management requires that we consider crop plants as active components of multi-trophic interactions. Plants can have both intrinsic (direct) defenses, as well as extrinsic (indirect) defenses against herbivores and pathogens and these defenses can be affected by plant nutrition and other environmental factors (Bernays & Chapman 1994). Examples of intrinsic defenses are production of toxins or digestibility reducers, or through physical defense by trichomes or toughness, or by a combination of the two, as with glandular trichomes or resins. Extrinsic defenses are when a plant benefits from the natural or applied enemies of herbivores (Price 1986). Extrinsic defenses may be brought about by the attraction of the third trophic level to damaged plants that have been induced to produce and emit volatile chemical signals (Agrawal 1998; Alborn et al. 1997; Cortesero et al. 1997; Paré & Tumlinson 1997a 1997b; Röse et al. 1998; Tumlinson et al. 1992; Turlings et al. 1990, 1991). In the only field test of induced resistance to herbivores and plant fitness, Agrawal (1998) found that previous damage by herbivores decreased subsequent herbivory and enhanced the seed mass of radishes. The previous study did not examine plant nutrition effects on herbivory and plant fitness, and recent studies indicate that these effects can have a large effect on a plant's ability to produce direct and indirect defenses against herbivory (Cortesero et al. unpublished data). In their study, Cotersero et al., found that high nitrogen levels decreased the release of induced volatiles of damaged cotton plants and the subsequent attraction to these plants by *Microplitis croceipes* (Cresson) a parasitoid of major cotton pests, *Helicoverpa zea* (Boddie) and *Heliothis virescens* (Boddie). In addition, cotton plants maintained their ability to produce antifeedants under all nitrogen levels tested, bu the high nitrogen plants received significantly higher leaf area damage than nitrogen applied at lower levels. Thus, awareness of plant effects on multi-trophic systems is essential in integrating plant breeding and biological control using natural enemies.

Our objective is to extend the study of Agrawal (1998) to a cotton system and to include plant nutrition with previous plant damage to test the their effects on plant fitness and the presence of plant-feeding insects and natural enemy species. Specifically, we will test the effects of various nitrogen levels in a cotton field conservation tilled with plants previously damaged and not previously damaged by *Spodoptera exigua* (Hübner) on the abundance of pests and predators, fruit production and damage, and total plant yield. A more focused study involving fitness effects of species showing strong response to these treatments will be the subject of subsequent field studies.

MATERIALS AND METHODS

A field located in the coastal plain region of southern Georgia, was planted in cotton, *Gossypium hirsutum* L. var. Deltapine acala 90 and sampled from July through September 1998. The field was conservation-tilled with a winter cover crop of Crimson clover (*Trifolium incarnatum* L. 'Dixie'). The field was previously treated with herbicides, Butoxone 175 and Gramoxone and fertilized with NPK 10-10-10 3x at 300 lb/acrecre. Cotton was planted on May 29 1998, no-till into Crimson clover with seed spacing at 3 seeds every 9.5 in.

Experimental Design

A set of experiments were conducted to test the effect of various nitrogen levels and damage of plants by the herbivore, *Spodptera exigua* Hübner on fruit production, damage of fruits and the presence of pest and natural enemy species. Nitrogen was applied twice at 0, 30, 60 & 120 lb/acre with ammonium nitrate (34-0-0). The nitrogen treatment was replicated 4 times resulting in 16 plots each 36 ft. long x 36 ft. wide. Sampled plants were separated from bordering plots and the edge of the field by 3 rows of cotton. Within each plot, 10 randomly chosen plants were designated for *S. exigua* damage and another 10 plants were not damaged. A damaged plant was obtained by placing 3-4 late 3rd and early 4th instar larvae of *S. exigua* , reared on artificial diet based on pinto beans as described by King & Leppla (1984) on 2 primary leaves from the middle of the plant and allowing feeding for 3 d. Larvae were held on the leaf and protected from predators by enclosing the leaf with a cotton bag (7 in. x 7 in.) with the opening gently secured to the petiole with a pipe cleaner. A total of 640 damaged and undamaged plants across 4 nitrogen levels and 4 replicates were sampled by 4 and 2 people on the first sampling and second date, respectively. Whole plant sampling for fruit production and plant damage occurred on July 22nd, 4 d prior to plant damage, and again on August 18th, 23 d after the larvae were placed on the plants. Whole plant sampling of insects occurred from July 31st to August 3rd, 5 days after the larvae were placed on the plant and again from August 20th to August 28th. Harvest occurred on November 6, 1998 and cotton yields were determined.

Sampling

Total fruit production and fruit damage was determined by counting the number of squares and bolls produced and those that were damaged. Percent plant damage was determined by taking the ratio of the total number of damaged squares and bolls to the total number of squares and bolls produced per plant. The total number of pests and beneficial insect species present was determined by counting the number of *Helicoverpa zea*, *Heliothis virecsens*, *Spodoptera exigua* and larvae, aphids, lacewing (*Chysoperla* & *Chrysopa* spp.) eggs, larvae and pupae, fire ants (*Solenopsis* spp.), coccinellid spp. adults, larvae, pupae and eggs, spiders and adult parasitoid sp. on each plant. Sampling for syrphid fly (*Syrphus* sp.), big-eyed bugs (*Geocoris* sp.), damsel bugs (*Nabis* spp.), assassin bugs (*Sinea diadema* and *Zelus* spp.), minute pirate bug (*Orius* spp), thrips (*Scolothrips sexmaculatus*) and stinkbug (*Podisus maculiventris*) predators and pests were also carried out but they were either absent or their numbers were so low that we do not report their presence.

Total nitrogen content of petioles and blades of cotton plants within each nitrogen treatment was determined by sampling plants 3 x during the study. Sampling occurred on July 22nd, August 21st and September 10th. Within each plot, 2 primary leaves and the petiole were removed from the middle of a randomly chosen cotton plant. A total of 16 samples on each date were obtained for mineral and nutrient analyses. A soil sample from each plot was obtained on August 7th for determination of total soil nitrates.

Statistical Analysis

The design was a randomized complete block with date classified as a super block. The effects of date, replication, nitrogen level, and their interaction on the percent nitrogen of petiole and blade samples after arcsine square root transformation were tested with GLM (SAS, SAS Institute, 1985). The effects of date, replication, nitrogen level, and their interaction on the total number of squares and bolls produced, the number of damaged squares, the number of damaged bolls, plant height and the percent damage of squares and bolls after arcsine square root transformation were tested with GLM (SAS, SAS Institute, 1985). Replication was nested within date and type III sums of squares were used for the error. The effects of replication, nitrogen level, plant damage and the interaction between nitrogen and plant damage on the total number of *H. zea*, *H. virescens* and *S. exigua* eggs (not hatched) and larvae, lacewing eggs (not hatched), larvae and pupae, aphids, fire ants, spiders and adult parasitoids were tested with GLM (SAS, SAS Institute, 1985). The number of aphids, and *H. zea* and *H. virescens* eggs were log-transformed to stabilize the variance. The effects of nitrogen on plant yield were tested with GLM (SAS, SAS Institute, 1985).

RESULTS

Blade, Petiole and Soil Nitrogen

The amount of nitrogen applied and the date of sampling significantly influenced the mean percent of leaf nitrogen (DF = 6, MS = 0.001, F = 2.73, P < 0.040). Significantly higher nitrogen was found in blades on the first sampling date (Fig. 1A). On the first and last sampling dates, the nitrogen level of the blades did not differ among nitrogen plots (Fig 1A). However, on the second sampling date, significantly higher leaf nitrogen was found in the plots with no nitrogen than those in the plots where 120 lb/acre nitrogen had been applied leading to the significant date by nitrogen interaction (Fig. 1A). On the second sampling date, leaf nitrogen was significantly lower in the highest nitrogen plots than leaf nitrogen from all other plots and for all sampling dates (Fig. 1A).

The mean percent of petiole nitrogen was significantly influenced by the date of sampling (DF = 2, MS = 0.352, F = 460.92, P < 0.001). Significantly higher petiole nitrogen was found on the second sampling date (Fig 1B).

Soil nitrates were significantly influenced by nitrogen treatment (DF = 3, MS = 142.67, F = 4.94, P < 0.028). Significantly higher soil nitrate levels were found in plots with 60 and 120 lb/acre than those from plots with 0 and 30 lb/acre nitrogen applied (Fig 1C).

The nitrogen level of plots and date significantly influenced plant height (Table 1). Plants in the plots with the highest nitrogen applied were significantly taller than plants in all other plots on both sampling dates (Fig. 1D).

Plant Damage and Yield

The total amount of fruit (squares and bolls) on the cotton plants was influenced by the amount of nitrogen applied (Table 1). Significantly more fruit was found on plants in plots with 120 lb/acre than 30-lb/acre nitrogen applied (Fig. 2A). Previous plant damage had no effect on the total amount of fruit on plants (Table 2).

The nitrogen applied to the plots significantly influenced the total number of damaged squares (Table 1, Fig. 2B). Significantly higher numbers of squares were damaged on plants in the plots with 120 lb/acre nitrogen applied than plants within plots from the same date with zero nitrogen applied, and the plants within plots from the first sampling period with 30 lb/acre nitrogen (Fig. 2B). Previous plant damage had no effect on the number of damaged squares within the second sampling date (Table 2).

The total number of damaged bolls on plants was significantly influenced by the sampling date and the nitrogen applied to the plots (Table 1). Very few bolls were damaged in the first sampling period because few bolls were present (Fig.2C). However, significantly higher numbers of bolls were damaged by the second period on the plants with 120 lb/acre nitrogen applied (Fig. 2C). Previous plant damage had no effect on the number of damaged bolls on the plants (Table 2).

The date of sampling and the nitrogen applied to plots significantly influenced the total percent of fruit damaged (Table 1). The proportion of damaged fruit was significantly higher on the first date in plots with no nitrogen applied than those plants of the same date with 30 lb/acre and all plots of the second date (Fig. 2D). On the second sampling date, a significantly higher proportion of the fruit was damaged on plants in plots with 120 lb/acre nitrogen applied (Fig. 2D). Previous plant damage had no effect on the percent of the fruit damaged (Table 2).

Plant yield was not significantly influenced by the nitrogen applied to the plots (DF = 3, MS = 13868.51, F = 0.44, P > 0.726).

Insects

The total number of *H. zea* and *H. virescens* eggs and larvae that were found on cotton plants was significantly influenced by the date of sampling and previous plant damage (Table 3). More eggs and larvae were found on the second sampling date on previously damaged plants but previous plant damage had no effect on the first sampling date (Fig. 3A & 3B). There was also a significant effect of date and nitrogen applied on the number of eggs found on plants (Table 3). Significantly more eggs were found on plants in plots with 120 lb/acre than 30 lb/acre nitrogen applied on the second sampling date and than all plots on the first sampling date (Fig. 3C). Pooling the 0 & 30 lb/acre and 60 & 120 lb/acre nitrogen treatments on the second sampling date indicate that significantly more *H. zea* and *H. virescens* eggs were oviposited on the high nitrogen plants that had been previously damaged (Fig. 3D, MS = 0.54, DF = 1, F = 4.16, P < 0.043 for the interaction between nitrogen and damage treatments). There was no significant effect of nitrogen and previous plant damage on the number of *S. exigua* egg masses or larvae (For egg masses: MS = 0.08, DF = 3, F = 2.11, P > 0.096 and MS = 0.01, DF = 1, F = 0.17, P > 0.678 for nitrogen and previous damage treatments, respectively. For larvae: MS = 45.51, DF = 3, F = 1.39, P > 0.243 and MS = 88.51, DF = 1, F = 2.71, P > 0.099 for nitrogen and damage treatments, respectively).

The mean number of aphids found on plants was influenced by the sampling date, previous plant damage and the amount of nitrogen applied (Table 3). Significantly more aphids were found on plants in the first than the second sampling date for all nitrogen levels and all plants previously damaged or undamaged (Fig. 4A). Previous plant damage and nitrogen applied had no significant effect on the number of aphids present in the first sampling date, but nitrogen application levels affected aphid numbers on the second sampling date which accounts for the date x nitrogen x damage interaction (Table 3, Fig. 4A & 4B). Pooling the number of aphids with respect to plant damage indicates that date and nitrogen have a strong effect on the number of aphids present (Fig. 4B, MS = 94.87, DF = 1, F = 332.54, P < 0.001 and MS = 2.29. DF = 3, F = 8.03, P < 0.001 for date and nitrogen treatments, respectively). Significantly more aphids were found on the first than the second sampling date (Fig. 4B). There was a non significant trend of increased numbers of aphids with nitrogen on the first sampling date with the highest numbers within plots with 60 lb/acre nitrogen (Fig. 4B).

The number of fire ants was significantly influenced by the amount of nitrogen applied and previous plant damage (Table 4). Although no significant differences were found among mean numbers of ants within all plots and plant damage and nitrogen, a trend showing increasing numbers of ants with increasing nitrogen level on undamaged plants and increasing numbers of ants on damaged plants in low nitrogen plots was apparent (Fig. 4C). Significantly more ants were found on the first than the second sampling date (Fig. 4D).

The mean number of lacewing eggs was significantly influenced by date, nitrogen and previous plant damage (Table 4). Significantly fewer lacewing eggs were found on the first than the second sampling date for all nitrogen applications and all plants previously damaged or undamaged (Fig. 5A). On the second sampling date, significantly higher numbers of lacewing eggs were found on previously damaged plants in plots with higher nitrogen (Fig 5A). Pooling plots with 0 & 30 and 60 &120 lb/acre nitrogen applied on the second sampling date show a significant influence of previously damaged plants with higher nitrogen on the mean number of lacewing eggs on plants (Fig. 5B, MS = 161.03, DF = 1, F = 6.02, $P < 0.016$ for the interaction of nitrogen & plant damage).

Sampling date and previous plant damage significantly influenced the number of lacewing larvae and pupae (Table 4). Significantly fewer lacewing larvae and pupae were found on the previously damaged than undamaged plants on the first sampling date although the number of eggs were the same (Fig. 5C & 5D). There were no differences in the mean number of lacewing larvae and pupae on plants on the second sampling date, but the trend follows the number of their eggs found on this date (Figure 5C & 5D).

The number of coccinellid adults was significantly influenced by the date of sampling (MS = 5.43, DF = 1, F = 17.61, $P < 0.001$). Significantly more adults were found on the first than the second sampling date (Mean number of adults per plant = 0.35 ± 0.66 (SD) & 0.18± 0.44 for first and second dates, respectively. N = 320 plants/date). The number of coccinellid eggs, larvae and pupae was also significantly influenced by sampling date (MS = 183.83, DF = 1, F = 13.31, $P < 0.001$). Significantly more coccienellid eggs, larvae and pupae were found on the first than the second sampling date (Mean number of eggs, larvae and pupae per plant = 1.55 ± 4.55 (SD) & 0.48 ± 2.67 for the first and second sampling date, respectively. N = 320 plants/date). There were no significant effects from the nitrogen and previous plant damage treatments or their interactions on the number of coccinellid adults or eggs, larvae and pupae.

The number of spiders was marginally influenced by the sampling date (MS = 2.63, DF = 1, F = 3.71, P = 0.055). Fewer spiders were found on the first than the second sampling date (Mean number of spiders per plant = 0.38 " 0.72 (SD) & 0.51 " 0.98 for the first and second sampling dates, respectively, N = 320 plants/date). There were no significant effects from the nitrogen and previous plant damage treatments or their interactions on the number of spiders present.

There were no significant effects from date, nitrogen and previous plant damage or their interactions on the number of adult parasitoids present.

DISCUSSION

There was a general pattern of increasing numbers of *H. zea* and *H. virescens* eggs with increasing nitrogen. In addition, previous plant damage had a significant effect on the number of eggs found only at the higher nitrogen levels. As a result of these ovipositions, the larvae of these species also follow this general trend. It is not clear what the mechanism(s) is that allows for increased presence of these species on damaged plants in high nitrogen plots. Predation/parasitism of eggs and larvae may be lower on high nitrogen plants that had been previously damaged, and/or moths may be responding to differences in the chemical/visual properties of high nitrogen plants that had been previously damaged. Plants were taller in the highest nitrogen plots and previous reports indicate that several lepidopteran species prefer to lay their eggs on taller plants with high nitrogen (Hern et al. 1996). We did not assess predation/parasitism of eggs and larvae in this study and the eggs had not hatched at the final sampling and prior to harvest. Further investigations of *H. zea* and *H. virescens* responses to higher nitrogen and previously damaged plants and the effect on their survival will be the subject of subsequent studies.

Aphids increase in numbers with nitrogen but at the highest nitrogen levels they begin to decline producing a dome shaped distribution across nitrogen amounts. The distribution of fire ants closely followed that of aphids. It may be that aphids respond to nitrogen in a linear manner and that the population on the highest nitrogen plots began to crash at an earlier date.

Total fruit production and damage was highest in the plots with the highest nitrogen, but neither fruit production nor damage was influenced by previous plant damage by *S. exigua*. The yield across all nitrogen levels, even in the plots where no nitrogen was applied (crimson clover only) were not significantly different.

Lacewing eggs follow the same pattern as *H. zea* and *H. virescens* eggs. More lacewing eggs were found on higher nitrogen plants that had been previously damaged. The number of larvae and pupae of these species follow this trend only on the second sampling date. Very few lacewing larvae or pupae were found throughout the season compared to the number of eggs that were found. Lacewing eggs hatch in 3-4 days, which suggests high larval and pupal predation early in the season. The lacewing eggs counted had not hatched at the time of sampling. Therefore, further investigations of lacewing responses to higher nitrogen and previously damaged plants and the effect on their survival will be the subject of subsequent studies.

There was a strong interaction between nitrogen, previous plant damage and the insect species present with a general pattern of increased fruit damage on higher nitrogen plants. Based on an earlier study showing that plants could improve their fitness through previous damage by attracting parasitoids of the pest species, we would expect to find decreased oviposition on previously damaged plants. We found higher oviposition in the case of *H. zea* and *H. virescens* and lacewings. However, this preference was more the case with high nitrogen, thus indicating that the nature of plant signals may have been altered by nitrogen rates in such a manner that the pest perceives a weakened plant and the predator perceives higher numbers of prey.

LITERATURE CITED

Agrawal, A. A. 1998. Induced responses to herbivory and increased plant performance. Science 279: 1201-1202.

Alborn, H. T., T. C. J. Turlings, T. H. Jones, G. Stenhagen, J. H. Loughrin & J. H. Tumlinson. 1997. An elicitor of plant volatiles from beet armyworm oral secretion. Science 276: 945-949.

Bernays, E. A. & Chapman. 1994. Host-plant Selection by Phytophagous Insects. Chapman & Hall, New York, NY.

Cortesoro, A. M., C. M. de Moraes, J. O. Stapel, J. H. Tumlinson & W. J. Lewis. 1997. Comparisons and contrasts in host-foraging strategies of two larval parasitoids with different degrees of host specificity. J. Chem. Ecol. 23: 1589-1606.

Hern, A., G. Edwards-Jones & R. G. McKinlay. 1996. A review of the pre-oviposition behaviour of the small cabbage white butterfly, *Pieris rapae* (Lepidoptera: Pieridae). Ann. appl. Biol. 128: 349-371.

King, E. G. & N. C. Leppla. 1984. Advances and Challenges in Insect Rearing. Agricultural Research Service, USDA. US Government Printing Office, Washington, DC.

Paré, P. W. & J. H. Tumlinson. 1997a. De novo biosynthesis of volatiles induced by insect herbivory in cotton plants. Plant Physiology 114: 1161-1167.

Paré, P. W. & J. H. Tumlinson. 1997b. Induced synthesis of plant volatiles. Nature 385: 30-31.

Röse, U. S. R., W. J. lewis & J. H. Tumlinson. 1998. Specificity of systemically released cotton volatiles as attractants for specialists and generalist parasitic wasps. J. Chem. Ecol. 24: 303-319.

Tumlinson, J. H., T. C. J. Turlings & W. J. Lewis. 1992. The semiochemical complexes that mediate insect parasitoid foraging. Agric. Zool. Reviews 5: 221-252.

Turlings, T. C. J., J. H. Tumlinson & W. J. Lewis. 1990. Exploitation of herbivore-induced plant odors by host-seeking parasitic wasps. Science 250: 1251-1252.

Turlings, T. C. J., J. H. Tumlinson, F. J. Eller & W. J. Lewis. 1991. Larval-damaged plants: source of volatile synomones that guide the parasitoid *Cotesia marginiventris* to the microhabitat of its host. Entomol. Exp. Appl. 58: 75-82.

Price, P. W. 1986. Ecological aspects of host plant resistance and biological control: interactions among three trophic levels. Pp. 11-30. In: Boethel, D. J. & R. D. Eikenbary (eds.). Interactions of plant resistance and parasitoids and predator insects. John Wiley & Sons, NY, 224pp.

Table 1. Anova Testing the Effects of Date, Replication Nested Within Date, Nitrogen Level, and the Interaction Between Date and Nitrogen on the Total Number of Squares and Bolls Produced (Total Fruit), the Number of Damaged Squares, the Number of Damaged Bolls, and the Percent Damage of Squares and Bolls after Arcsine Square Root Transformation. N = 640 Cotton Plants.

Factor	DF	MS	F
		Total Fruit	
Date	1	60314.64	454.16***
Replication (Date)	6	342.32	2.58*
Nitrogen	3	496.94	3.74**
Date x Nitrogen	3	50.26	0.38
		Damaged Squares	
Date	1	1.81	0.57
Replication (Date)	6	46.67	14.75***
Nitrogen	3	17.42	5.50**
Date x Nitrogen	3	6.85	2.17
		Damaged Bolls	
Date	1	124.26	135.29***
Replication (Date)	6	2.00	2.18*

Nitrogen	3	6.47	7.05***
Date x Nitrogen	3	6.77	7.37***
% Total Fruit Damaged			
Date	1	0.09	2.23
Rep (Date)	6	0.40	10.05***
Nitrogen	3	0.26	6.59***
Date x Nitrogen	3	0.21	5.16**
Plant Height			
Date	1	34061.81	1737.72***
Rep (Date)	6	1216.38	62.06***
Nitrogen	3	264.61	13.50***
Date x Nitrogen	3	72.39	3.69*

Significant at *0.05, **0.01, ***0.001

Table 2. Anova Testing the Effects of Replication, Nitrogen Level, Beet Armyworm Damage, and Their Interaction on the Total Number of Squares and Bolls Produced (Total Fruit), the Number of Damaged Squares, the Number of Damaged Bolls, and the Percent Damage of Squares and Bolls after Arcsine Square Root Transformation. N = 320 Cotton Plants.

Factor	DF	MS	F
Total Fruit			
Rep	3	308.50	1.57
Dud	1	252.05	1.28
Nitrogen	3	220.62	1.12
Damage x Nitrogen	3	315.29	1.60
Damaged Squares			
Rep	3	59.71	19.61***
Dud	1	0.61	0.20
Nitrogen	3	13.66	4.49**
Damage x Nitrogen	3	0.67	0.22
Damaged Bolls			
Rep	3	3.98	2.17
Dud	1	1.01	0.55
Nitrogen	3	13.23	7.22***
Damage x Nitrogen	3	0.64	0.35
% Total Fruit Damaged			
Rep	3	0.38	18.59***
Dud	1	0.02	0.93
Nitrogen	3	0.23	11.35***
Damage x Nitrogen	3	0.01	0.39

Significant at *0.05, **0.01, ***0.001

Table 3. Anova Testing the Effects of Date, Replication, Nitrogen Level, Beet Armyworm Damage and Their Interactions on Log-transformed Number of *H. Zea* & *H. Virescens* Eggs, *H. Zea* & *H. Virescens* Larvae & Pupae, Aphids and Fire Ants. Type Iii Sums of Squares for Error. N = 640 Cotton Plants.

Factor	DF	MS	F
H. zea, H. virescens eggs			
Date	1	1.52	12.97***
Replication (Date)	6	2.83	24.13***
Nitrogen	3	0.22	1.84
Damage	1	0.68	5.80*
Date x Nitrogen	3	0.10	0.88
Date x Damage	3	0.41	3.53*
Nitrogen x Damage	1	0.74	6.32*
Date x Nitrogen x Damage	3	0.16	1.38
H. zea, H. virescens larvae			
Date	1	10.00	30.19***
Replication (Date)	6	2.23	6.73***
Nitrogen	3	1.10	3.33*
Damage	1	2.50	7.55**
Date x Nitrogen	3	0.62	1.85
Date x Damage	3	0.35	1.07

Nitrogen x Damage	1	2.03	6.11*
Date x Nitrogen x Damage	3	0.18	0.54
Aphids			
Date	1	94.87	336.50***
Replication (Date)	6	53.81	190.85***
Nitrogen	3	2.29	8.13***
Damage	1	0.26	0.92
Date x Nitrogen	3	0.33	1.18
Date x Damage	3	1.01	3.57*
Nitrogen x Damage	1	0.15	0.52
Date x Nitrogen x Damage	3	0.98	3.49*

Significant at *0.05, *0.01, ***0.001

Table 4. Anova Testing the Effects of Date, Replication, Nitrogen Level, Beet Armyworm Damage and Their Interactions on the Number of Lacewing Eggs, Lacewing Larvae & Pupae and Fire Ants. Type Iii Sums of Squares for Error. N = 640 Cotton Plants.

Factor	DF	MS	F
Lacewing eggs			
Date	1	2476.7	136.61***
Replication (Date)	6	275.60	15.20***
Nitrogen	3	103.59	5.71***
Damage	1	169.13	9.33**
Date x Nitrogen	3	23.19	1.28
Date x Damage	3	9.64	0.53
Nitrogen x Damage	1	161.00	8.88**
Date x Nitrogen x Damage	3	56.26	3.10*
Lacewing larvae & pupae			
Date	1	0.08	1.06
Replication (Date)	6	0.12	1.72
Nitrogen	3	0.07	1.00
Damage	1	0.13	1.75
Date x Nitrogen	3	0.04	0.60
Date x Damage	3	0.56	7.78**
Nitrogen x Damage	1	0.05	0.71
Date x Nitrogen x Damage	3	0.02	0.31
Fire ants			
Date	1	153.08	4.20*
Replication (Date)	6	216.00	5.92***
Nitrogen	3	36.09	0.99
Damage	1	7.01	0.19
Date x Nitrogen	3	100.57	2.76*
Date x Damage	3	29.21	0.80
Nitrogen x Damage	1	3.16	0.09
Date x Nitrogen x Damage	3	36.73	1.01

Significant at *0.05, **0.01, ***0.001

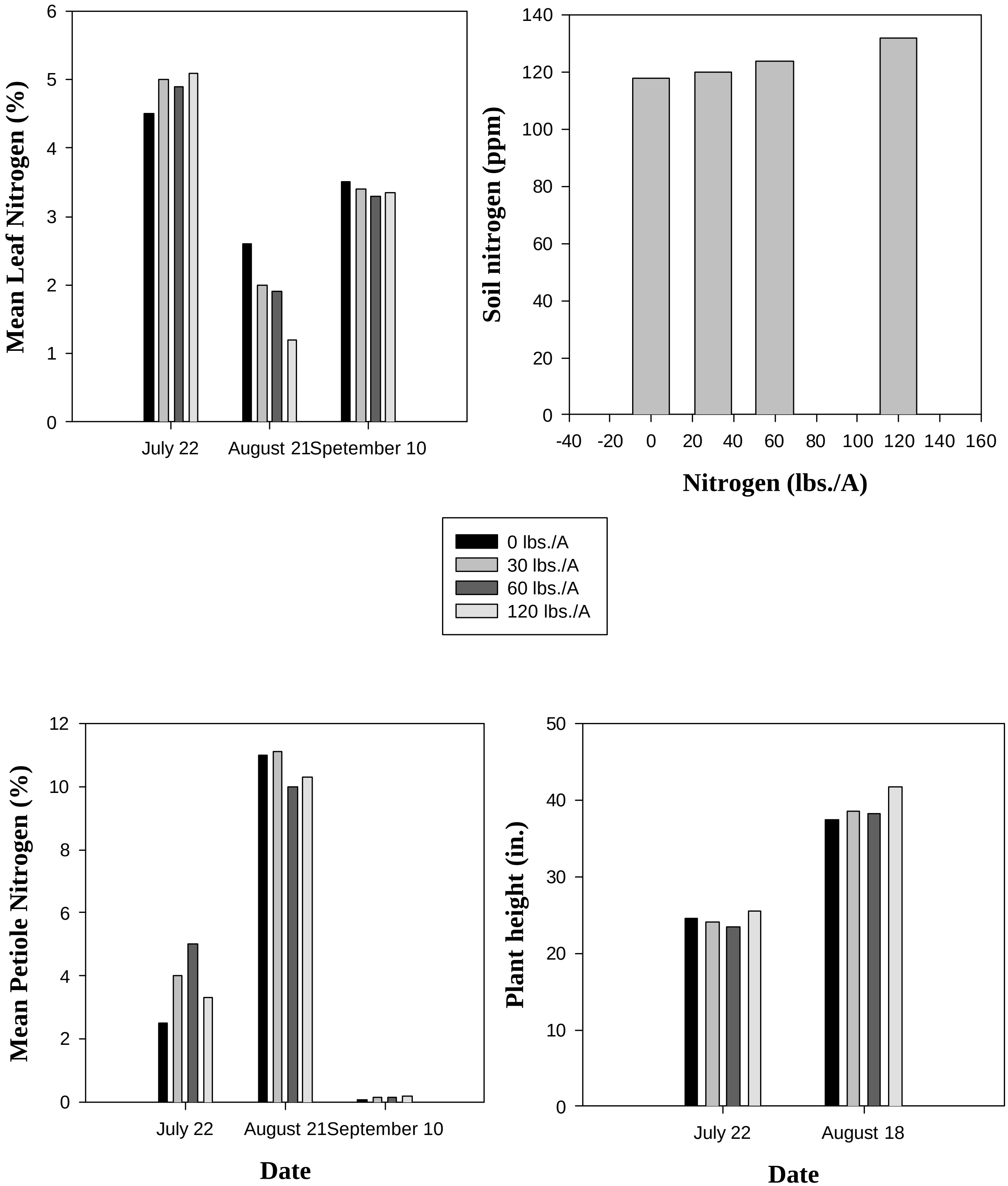


Figure 1. Mean percentage of leaf (A) and petiole (B) nitrogen across sampling dates. Mean parts per million (ppm) of soil nitrogen (C), and mean plant height (D). Samples were taken from 4 plots with 0, 30 60 & 120 lb/acre nitrogen applied across 4 replications, *n* = 16

plots (C). Treatments with different letters are significantly different at $p < 0.05$.

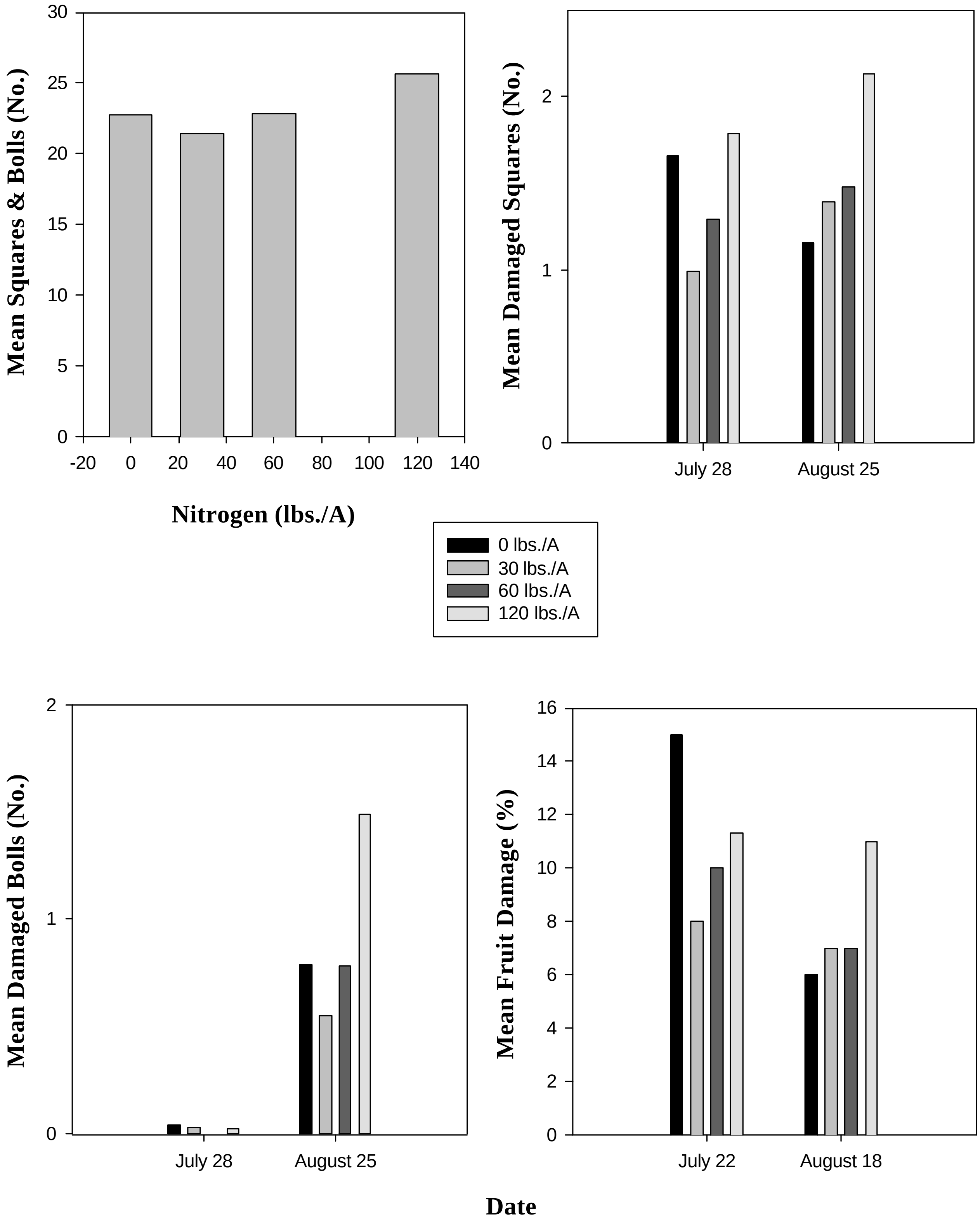


Figure 2. Mean number of squares and bolls per nitrogen applied to plots (A), mean number of damaged squares (B) and damaged bolls (C) per sampling date and nitrogen applied to plots, and mean percent of square and boll damage per sampling date and nitrogen applied to plots (D), n = 640 plants. Treatments with different letters are significantly different at p < 0.05.

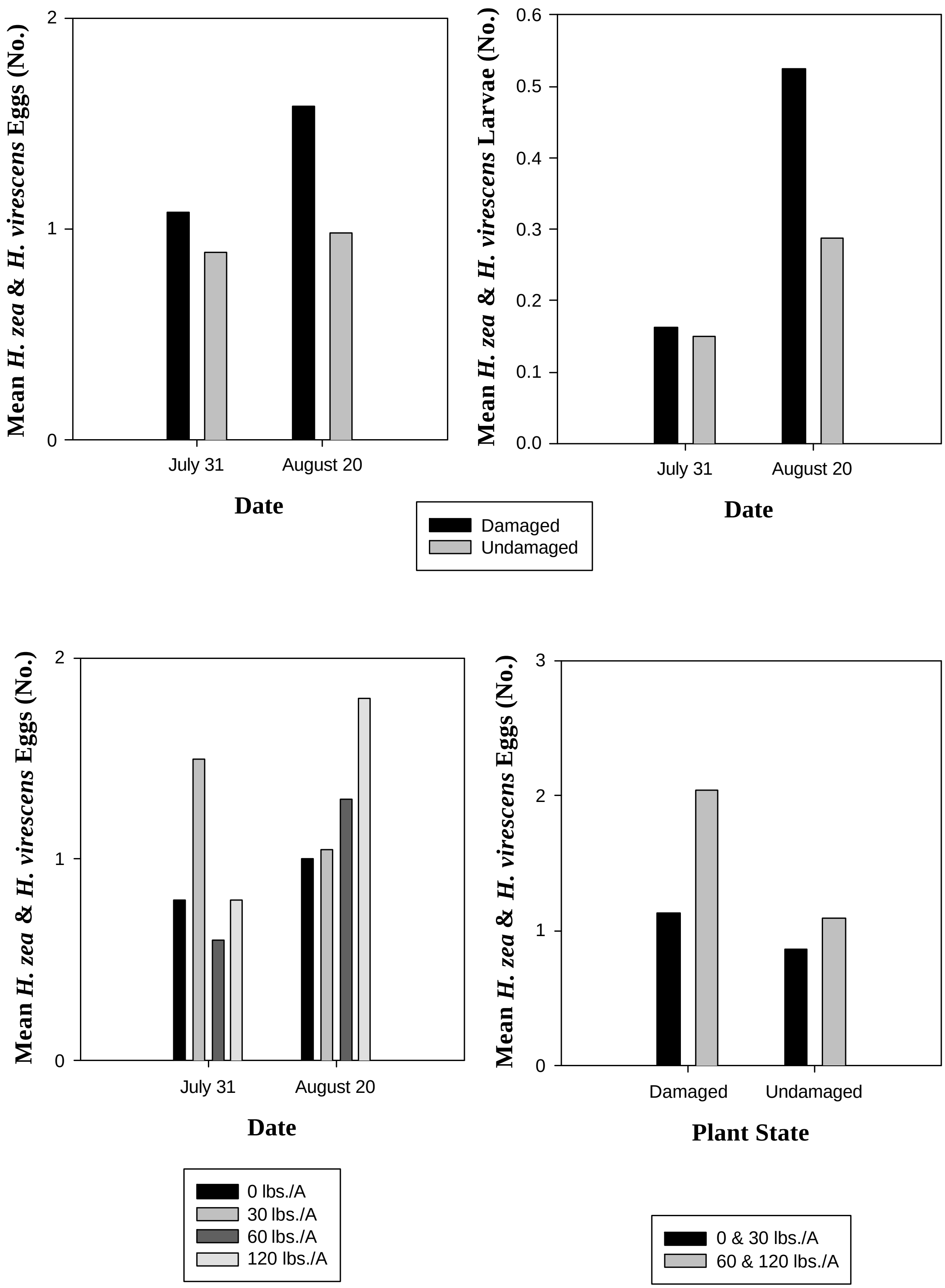
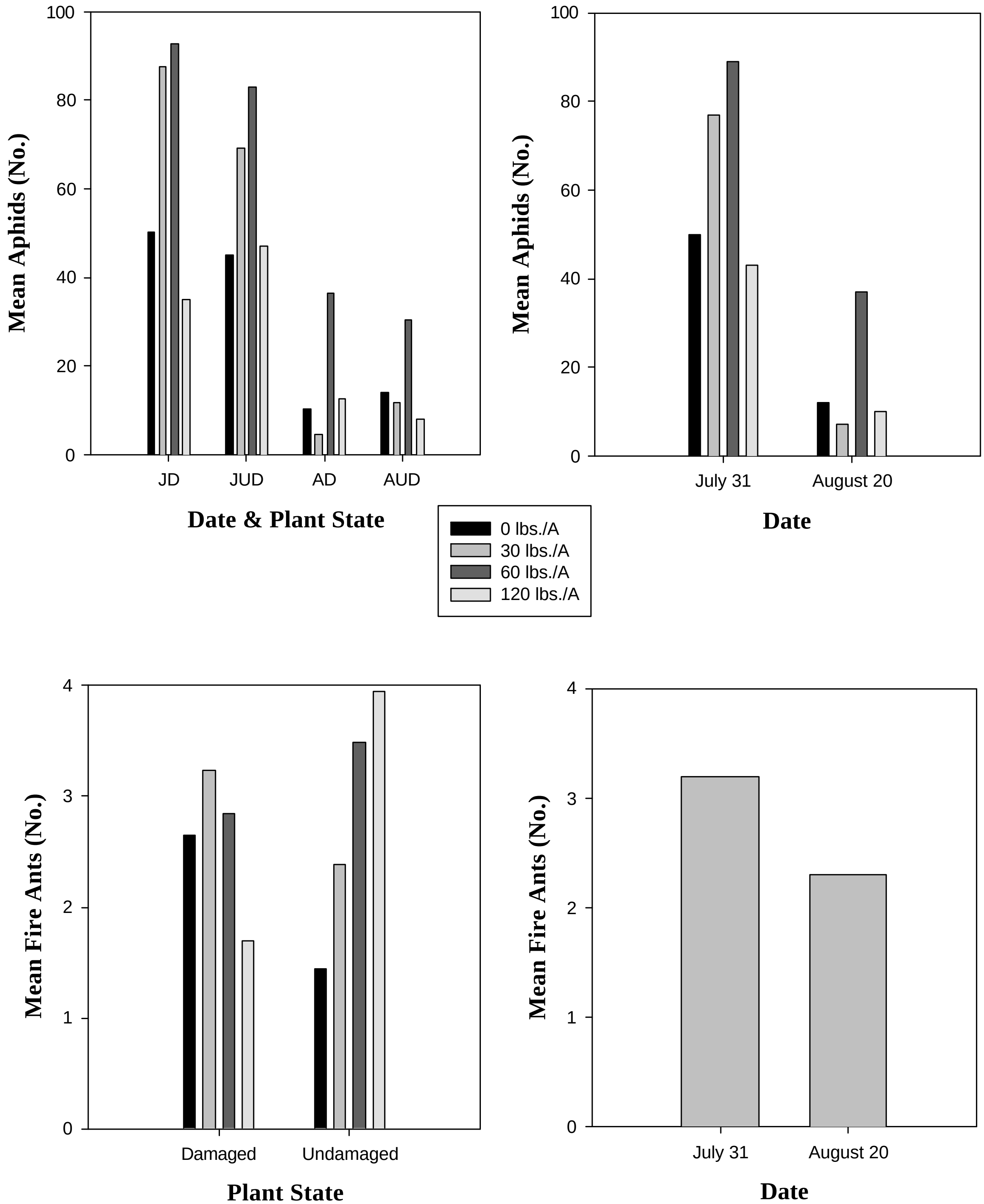


Figure 3. Mean number of *Helicoverpa zea* and *Heliothis virescens* eggs (A) and larvae (B) per sampling date on previously damaged and not previously damaged plants, and per nitrogen applied to plots (C), *n* = 640 plants. Mean number of *H. zea* and *H. virescens* eggs on August 20 for previously damaged and not previously damaged cotton plants after pooling nitrogen into 0& 30 and 60 & 120 lb/acre nitrogen applied to plots (C), *n* = 320 plants. Treatments with different letters are significantly



different at $p < 0.05$. Figure. 4. Mean number of aphids on July (J) and August (A) per previously damaged (D) and not previously damaged (UD) cotton plants across nitrogen applied to plots (A), and across sampling dates and nitrogen applied to cotton plots (B). Mean number of fire ants per previously damaged and not previously damaged plants across nitrogen applied to plots (C) and across sampling dates (D). N = 640 plants. Treatments with different letters (nested within date in Fig.4A)

are significantly different at $p < 0.05$.

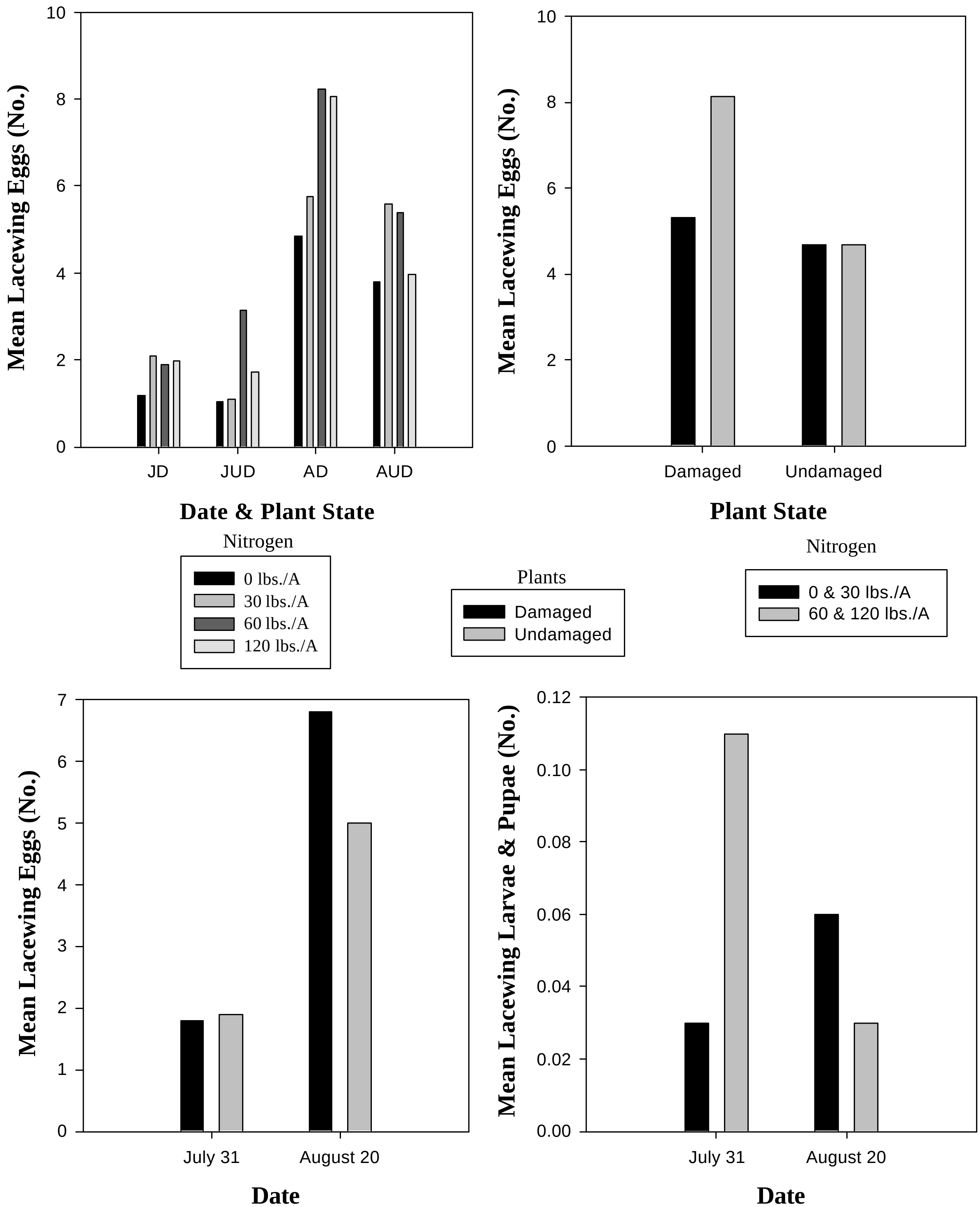


Figure. 5. Mean number of lacewing eggs on July (J) and August (A) per previously damaged (D) and not previously damaged (UD) cotton plants across nitrogen applied to plots (A), *n* = 640 plants. Mean number of lacewing eggs on August 20 for previously damaged and not previously damaged cotton plants after pooling nitrogen into 0 & 30 and 60 & 120 lb/acre nitrogen applied to plots (B), *n* = 320 plants. Mean number of lacewing eggs (C) and larvae & pupae (D) across previously damaged and undamaged plants and sampling dates, *n* = 640 plants. Treatments with different letters (nested within date in fig. 5A) are significantly different at *p*

< 0.05.

THE USE OF PLANT MAPPING FOR EVALUATING STRUCTURE AND YIELD OF SOYBEAN PLANTS

Terry Keisling[1] and Paul Counce[2]

AUTHORS: [1] Northeast Research and Extension Center, University of Arkansas, P.O. Box 48, Keiser, AR 72351; [2]Rice Research and Extension Center, University of Arkansas, P.O. Box 351, Stuttgart, AR 72160.
REFERENCE: J. E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. Several field situations and experiments were selected to provide examples of how soybean fruit mapping data could be used to more effectively delineate and understand responses. Field situations mapped included in-the-row subsoiling, severe drought, restricted soil rooting depths, variety tests, wheat residue test, and a representative production population. The methods of presentation used were mainstem nodes, nodes-above-ground, nodes-from-stem-end. Fruit mapping provided insight into the nature of some responses and was helpful in documenting morphological responses and characteristics. Future utility of fruit mapping depends upon identification of the most appropriate method for presenting the map data in order to illustrate the responses most clearly. These are only three of many possible ways to present the mapping data.

INTRODUCTION

Until its recent adaptation by cotton (*Gossypium hirsutum* L.) agronomists, plant mapping has not been used extensively for crop management (Bourland et al., 1990, 1992a, and 1994a; Klein et al., 1994; Oosterhuis et al., 1994; and Zhang et al., 1994). Cotton agronomists originally used plant maps (I) to evaluate the accuracy of computer predictions of plant development (Albers, 1990 and Smith et al., 1986) and (ii) to evaluate the effect of growth regulators on the cotton plant (Bourland and Watson 1990). The use of plant maps progressed rapidly to (i) determining which fruiting locations contribute most to yield (Bourland et al., 1990; Constable, 1991; and Jenkins et al., 1990ab) and (ii) using plant flowering, fruit set, and nodal characteristics to plan management practices such as end of season management for insect control and harvest aid applications (Bagwell and Tugwell, 1992; Bernhart et al., 1996; Bourland et al., 1992b and 1994b; Cochran et al., 1994; and Oosterhuis et al., 1992 and 1994). Plant mapping at the end of the season is a proposed tool for growers to identify production problems (Plant and Kerby, 1995.)

Keisling and Counce (1997) present a method to map fruit on a soybean (*Glycine max* L. Merr.) plant. The mapping procedure consists of recording the location and fruit characteristics in a numerical format. Soybean fruit mapping (if it parallels that of cotton) could become a powerful management tool. It may also be helpful in documenting and understanding soybean morphological responses to the environment.

The objectives of this paper were (i) to provide examples of potential applications of soybean fruit mapping and (ii) to show how fruit mapping aids understanding of soybean responses to the environment.

MATERIALS AND METHODS

Several diverse situations were selected to map fruit according to the method described by Keisling and Counce (1997). These situations were selected to show potential of the method for illustrating morphological differences. The selected situations included drought, row spacing, in-the-row subsoiling, variety testing, planting in wheat straw, population characteristics in a production field, and lodging. Location, soil type, cultivar, planting, and plant growth stage at sampling date are given in Table 1. Non-specified agronomic practices in each situation were commensurate with normal production practices used in the area.

Drought

A field exhibiting severe drought stress was selected. Plants in this field were dying. The seedbed was bedded in 38 in rows in the fall and remained a stale seedbed. Both live and dead plants from 1 m of row were selected for mapping.

Soil Depth

The field was planted in 6-in and 12-in drilled rows. Plant spacings were the same within each row spacing, giving plant populations of 612,000 plants per ha for 6-in row spacing and 306,000 plants per ha for 12-in row spacing. The field has a fragipan which varies in depth across the field: <12 in and 12-24 in. Plants were selected from 48 in row lengths per plot in five replications for mapping.

Wheat Straw

A split plot with main plots being fallow or cropped to wheat and subplots being soybean cultivar was sampled. The field was irrigated to eliminate water stress. Fifty varieties were planted no-till in 19-in rows. Certain varieties showed a dramatic response to the presence of wheat stubble. 'Hartz 5545' was chosen for mapping because height was reduced approximately 50% in the presence of wheat straw. One representative plant from each treatment was mapped.

In-the-row Sub-soiling

A tillage test received a conventional bedding treatment and in-the-row subsoiling system. Land preparation consisted of disking, chiseling and forming a crowned bed with disk bedders for seedling rows 30 in apart. The in-the-row subsoiling treatments were about 16 in deep immediately under the seedling row. The beds were dragged off just prior to planting. Plants from a 24 in length of row were mapped.

Growth Habit and In-season-progression

A cultivar test was chosen. In the fall of 1993, the field was disced, land-planed and bedded in 38-in rows. The beds were dragged off and bedded again in the spring immediately prior to planting. Plants for mapping were taken from 6 in length of row in each of four replications. Several determinate and indeterminate cultivars were mapped with similar results. 'Williams 82' and 'Hutcheson' were chosen as representatives of the two growth habits.

Population Dynamics

In the border of the cultivar test described above, soybean plants from 39 in of row were mapped with plant locations recorded. Yields per node on each plant were recorded to demonstrate potential utility of fruit mapping for delineating fruit distribution differences between high and low yielding plants.

Lodging

Locations with lodged plants in the same field as used for soil depth studies were selected. These plants lodged approximately at the V14 growth stage (last week in July.) The rows spaced at 6-in with 612,000 plants per ha were lodged, and the 12-in spaced rows at 306,000 plants per ha were upright.

RESULTS AND DISCUSSION

Drought

The response of soybeans to inadequate water provide one set of examples of the potential value of the maps. Fruit maps (Fig. 1a and b) indicate that plants that had recently died had a much different fruit distribution along the mainstem nodes. The live plants tended to have more fruit at lower mainstem nodes than at upper mainstem nodes. The dead plants tended to have a reverse distribution of fruit along the mainstem. This fruiting pattern is dramatically depicted using cumulative graphs as in Fig. 1c and d. The fruit load on dead plants is approximately 30% higher than on live plants and is shown with the cumulative graphs. There is no apparent difference in the relative maturity of the fruit. The pods classified as R5 on the dead plants did not separate at the peduncle even if pulled until the pods split, but those classed as R4 easily separated at the peduncle. This indicates that pods in the R5 growth stage will not abort under drought stress even when severe enough to kill the plants. Severe drought damage leading to the death of some plants compared to survival for other plants provided us with an opportunity to illustrate plant characteristics of surviving versus dead plants.

Soil Depth

The narrow rows at the high populations resulted in a yield increase (p=0.01) compared to wide rows and low population on shallow soil but not on deeper soil. Mature fruit maps on a per plant basis indicated the following:

(1) On shallow soil (Fig 2a and c), plants in close rows and high population had some yield and branching characteristics similar to plants on wide rows and low population.
(2) On deeper soil (Fig 2e and g), the lower population on wide rows had dramatically higher yield and branching on a per plant basis than higher population on narrow rows.

Presenting the fruit mapping characteristics on an area basis (Fig 2b, d, f, and h) indicated that this yield increase was a result of more fruit per area. Plants in wider rows at lower populations on shallow soil do not produce fruit on branches as they did on deeper soil.

Wheat Straw

The maps of the representative plants are for one sampling date only. Checking the number and accumulation of fruit classified as R2, R3, R4, and R5 (Fig. 3a through e) shows the plant without wheat straw to have substantially more fruit in each of these categories. The fruit classification methods are described in Keisling and Counce (1997). However, fruit classified as R6 (Fig. 3e) indicates that the plant with straw has essentially twice as many pods. This indicates that the wheat straw plots had a more mature fruit load than those plots without wheat straw.

In-the-row Subsoil

Fruit mapping indicated that plants from subsoil treatments (Fig. 4a) had a dramatic increase in the number of fruit located at mainstem nodes 4 through 8 with some increase occurring until node 13. Twice as many mature pods per plant were on the subsoiled than on the non-subsoiled treatment (Fig. 4b) . The pods on non-subsoiled plants began at mainstem node four and continued to node 22. For the sub-soiled treatments, pods continued for five additional nodes. The curve for the number of branch nodes with fruit is very similar to that obtained for fruit per mainstem node (Fig. 4a) indicating that the production of fruiting branches was the primary source of yield increase from subsoiling.

Growth Habit

The three methods of presenting fruit distribution for the soybean plant (mainstem nodes, nodes-from-stem-end, and nodes-above-ground) provide different perspectives of the plant. We exploit a well known growth habit and fruit set difference for determinate and indeterminate soybeans. A total of 15 determinate and indeterminate cultivars were mapped. We chose to present the maps for indeterminate cultivar 'Williams 82' and determinate cultivar 'Hutcheson' (Fig. 5). 'Williams 82' had few branches, and 'Hutcheson' had many branches. Weight of seed per plant was unrelated to the small amount of branching on 'Williams 82', but weight of seed per plant was directly related to branch number in 'Hutcheson' (Fig. 5a,b). Seed was distributed uniformly along nodes-from-stem-end for 'Williams 82' and was skewed to the first five nodes from the end of a stem for 'Hutcheson' (Fig. 5c,d). Weight of seed was distributed more uniformly along nodes-above-ground for 'Williams 82' compared to 'Hutcheson' (Fig. 5e,f). This example illustrates how the mapping procedure can be used to delineate differences in fruit location and branching patterns.

In-season-progression

Fruit maps illustrate the progression of the crop toward maturity (Fig. 6 a, b, and c). Since the time progression is for different plants at each sampling date, there is variation involved in the fruit load and classification with time of sampling. It is interesting to note that the number of fruit that was ultimately harvested was already on the plant in July. The peak on the August 18 curve (Fig. 6c) is a result of a flush of flowers that did not result in mature fruit (Fig. 6d). The curves of fruit number and weight of seed are essentially identical in shape (Fig. 6d). This was also true for many other varieties not shown. The correlation coefficient between weight of seed and seed number for plants treated the same from all studies was 0.99+ and highly significant statistically. This indicates that for many purposes fruit counts maybe as good as seed weights or with a subsample can be used to estimate seed weight.

Population Dynamics

The fruit mapping data can easily be used to produce useful interpretations. We illustrated how yields of plants vary (Fig. 7a and b). Using simple graphical techniques and cumulative percent showed that about 20% of the plants accounted for about 50% of the yield (Fig. 7b). About 70% of the seed yield for this set of data occurs in the first four nodes from stem end (Fig. 7c). About 70% of seed yield is distributed between nodes 7 and 14 above the ground (Fig. 7d). Fruit mapping indicated that higher yielding plants (Fig. 8a, b, and c) had characteristic yields distributions whichever mapping system was utilized. The node-from-stem-end (Fig. 8c) shows the most dramatic differences in fruiting patterns.

Lodging

Plants in narrow rows that lodged tended to have the same number of mainstem nodes as plants in wider rows that did not lodge (Fig. 9). However, there was a dramatic increase in fruit (Fig. 9a) and branch nodes (Fig. 9b) arising from about mainstem nodes 4 through 6. The lodged plants produced more branches nodes and fruit at these nodes.

CONCLUSIONS

Soybean fruit mapping has the potential to be a useful tool. We demonstrated how it could be used to show cultivar differences, to delineate fruit distributions, and to define relative contributions of different nodal positions and plant structures. It may help the understanding of soybean yield responses to the environment. Perhaps this understanding will in turn help us to better manage the soybean crop. Future utility of fruit mapping depends upon identification of the most appropriate method for presenting the map data in order to illustrate the responses most clearly. These are only three of many possible ways to present the mapping data.

ACKNOWLEDGMENT

We gratefully acknowledge the Arkansas Soybean Promotion Board for providing a financial grant making this research possible.

LITERATURE CITED

Albers, D.W. 1990. GOSSYM-COMAX nitrogen recommendations: strengths and weaknesses. *in* W.N. Miley and D.M. Oosterhuis (eds.) Nitrogen nutrition of cotton: practical issues. Amer. Soc. Of Agron., pp. 53-58.

Bagwell, R.D., and N.P. Tugwell. 1992. Defining the period of boll susceptibility to insect damage in heat-units from flower. *in* Proc., Beltwide Cotton Conf., 6-12

Jan., Nashville, TN, National Cotton Council, Memphis, TN. p. 767-768.

Bernhardt, J.L., J.R. Phillips, and N.P. Tugwell. 1986. Position of the upper most white bloom defined by node counts as an indicator for termination of insecticide treatments for cotton. J. Econ. Entomol. 79:1430-1438.

Bourland, F.M., D.M. Oosterhuis, and N.P. Tugwell. 1992. Concept for monitoring the growth and development of cotton plants using main-stem node counts. J. Prod. Agric. 5:532-538.

Bourland, F.M., D.M. Oosterhuis, N.P. Tugwell, M.J. Cochran, and J.P. Zhang. 1994. Timing cotton defoliation by nodal development. Ark. Agric. Exp. Stn. Spec. Rpt. 162:32-38.

Bourland, F.M., S.J. Stringer, and J.D. Halter. 1992. Maturity of cotton cultivars in Arkansas as determined by nodes above white flower. *in* Proc. Beltwide Cotton Conf., 6-12 Jan., Nashville, TN, National Cotton Council, Memphis, TN. p. 560-563.

Bourland, F.M., N.P. Tugwell, D.M. Oosterhuis, S.J. Stringer, J.R. Phillips, and M.J. Cochran. 1990. Reading the cotton plant for efficient management. Ark. Agric. Exp. Stn. Spec. Rpt. 144:45-49.

Bourland, F.M., N.P. Tugwell, D.M. Oosterhuis, and M.J. Cochran. 1994. Cotton plant monitoring: the Arkansas system (an overview). *in* Proc. Beltwide Cotton Conf., 5-8 Jan., San Diego, CA National Cotton Council, Memphis, TN. p. 1280-1281.

Bourland, F.M. and C.E. Watson, Jr. 1990. COTMAP, a technique for evaluating structure and yield of cotton plants. Crop Sci. 30:224-226.

Cochran, M.J., N.P. Tugwell, D.M. Danforth, C.D. Klein, and J.P. Zhang. 1994. The economic potential of plant monitoring to guide the termination of late season insect control in Arkansas. *in* Proc. Beltwide Cotton Conf., 5-8 Jan., San Diego, CA National Cotton Council, Memphis, TN. p. 914-915.

Constable, G.A. 1991. Mapping the production and yield of fruit on field-grown cotton. Agron. J. 83:374-378.

Fehr, W.R. and C.E. Caviness. 1977. Stages of Soybean Development. Iowa State Univ. Spec. Rep. 80.

Jenkins, J.N., J.C. McCarty, and W.L. Parrott. 1990a. Fruiting efficiency in cotton: boll size and boll set percentage. Crop Sci. 30:365-369.

Jenkins, J.N., J.C. McCarty, and W.L. Parrott. 1990b. Competition between adjacent fruiting forms in cotton. Crop Sci. 30:857-860.

Keisling, T.C., and P.A. Counce. 1997. An encoding process for morphological analysis of soybean fruit distribution. Crop Sci. 37:1665-1669.

Klein, C.D., D.M. Oosterhuis, F.M. Bourland, M.J. Cochran, and N.P. Tugwell. 1994. Practical on-farm experience utilizing the Arkansas system of crop monitoring. *in* Proc. Beltwide Cotton Conf., 5-8 Jan., San Diego, CA National Cotton Council, Memphis, TN. p. 1288-1290.

Plant, R.E., and T.A. Kerby. 1995. CPM: software for cotton fruit mapping. Agron. J. 87:1143-1147.

Oosterhuis, D.M., F.M. Bourland, and N.P. Tugwell. 1992. Basis for nodes above white flower cotton monitoring system. Ark. Farm Res. 41(5):3-5.

Oosterhuis, D.M., F.M. Bourland, N.P. Tugwell, and M.J. Cochran. Terminology and concepts related to crop monitoring, maturity and defoliation. Ark. Agric. Exp. Stn. Spec. Rpt. 162:239-249.

Smith, W.C., Jr., B.A. Schumacher, and C.W. Kennedy. 1986. A BASIC software program for mapping and analysis of fruit location on cotton plants. Project Rpt., Dept. of Agron., Lou. Agric. Exp. Stn., Baton Rouge, LA. p. 50-52.

Zhang, J.P., N.P. Tugwell, M.J. Cochran, F.M. Bourland, D.M. Oosterhuis, and C.D. Kein. 1994. COTMAN: A computer-aided cotton management system for late-season practices. *in* Proc. Beltwide Cotton Conf.., 5-8 Jan., San Diego, CA National Cotton Council, Memphis, TN. p. 1286-1287.

Table 1. Name, location, soil type, cultivar and planting date for field experiments.

Study No.	Study Name	Nearest Arkansas Town	Soil Classification	Cultivar	1994 Planting Date	Growth[2] Stage When Sampled
1	Drought	Keiser	Sharkey silty clay[1]	Hutcheson	6 May	R6
2	Soil Depth	Colt	Calloway silt loam	Walters	28 May	R8
3	Wheat straw	Rowher	Herbert silt loam	Hartz 5545	10 June	R6
4	Subsoiling	Conway	Roxanna very fine sandy loam	NKRA452	23 April	R8
5	Growth habit	Keiser	Convent fine sandy loam	----	18 April	R8
6	Fruiting progress	Keiser	Convent fine sandy loam	Manokin	18 April	R4,R6,R8
7	Population	Keiser	Convent fine sandy loam	Manokin	18 April	R8
8	Lodging	Colt	Calloway silt loam	Walters	28 May	R8

[1] The soil was a small (4 m diameter) inclusion in a soil mapped as Sharkey silty clay.
[2] Growth stage is according to Fehr and Caviness (1977).

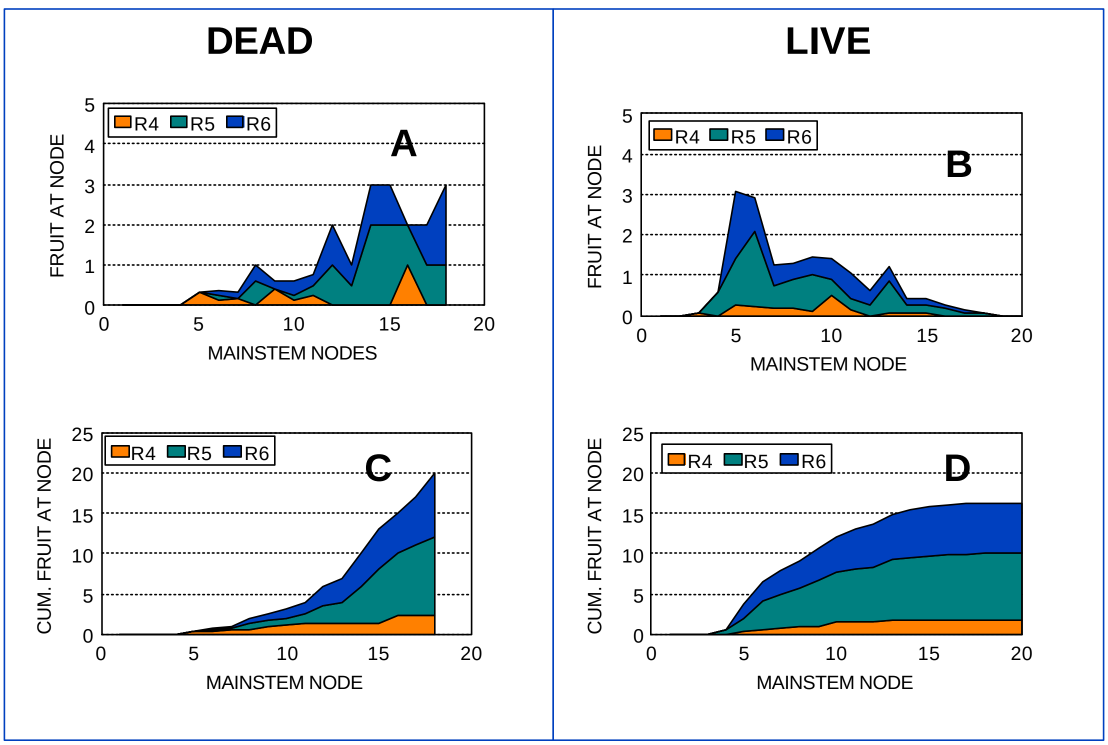


Fig. 1. Number of fruit versus mainstem node of plants under severe drought stress. A and C are for dead plants. B and D are for plants still living. Cumulative data is taken from the ground up.

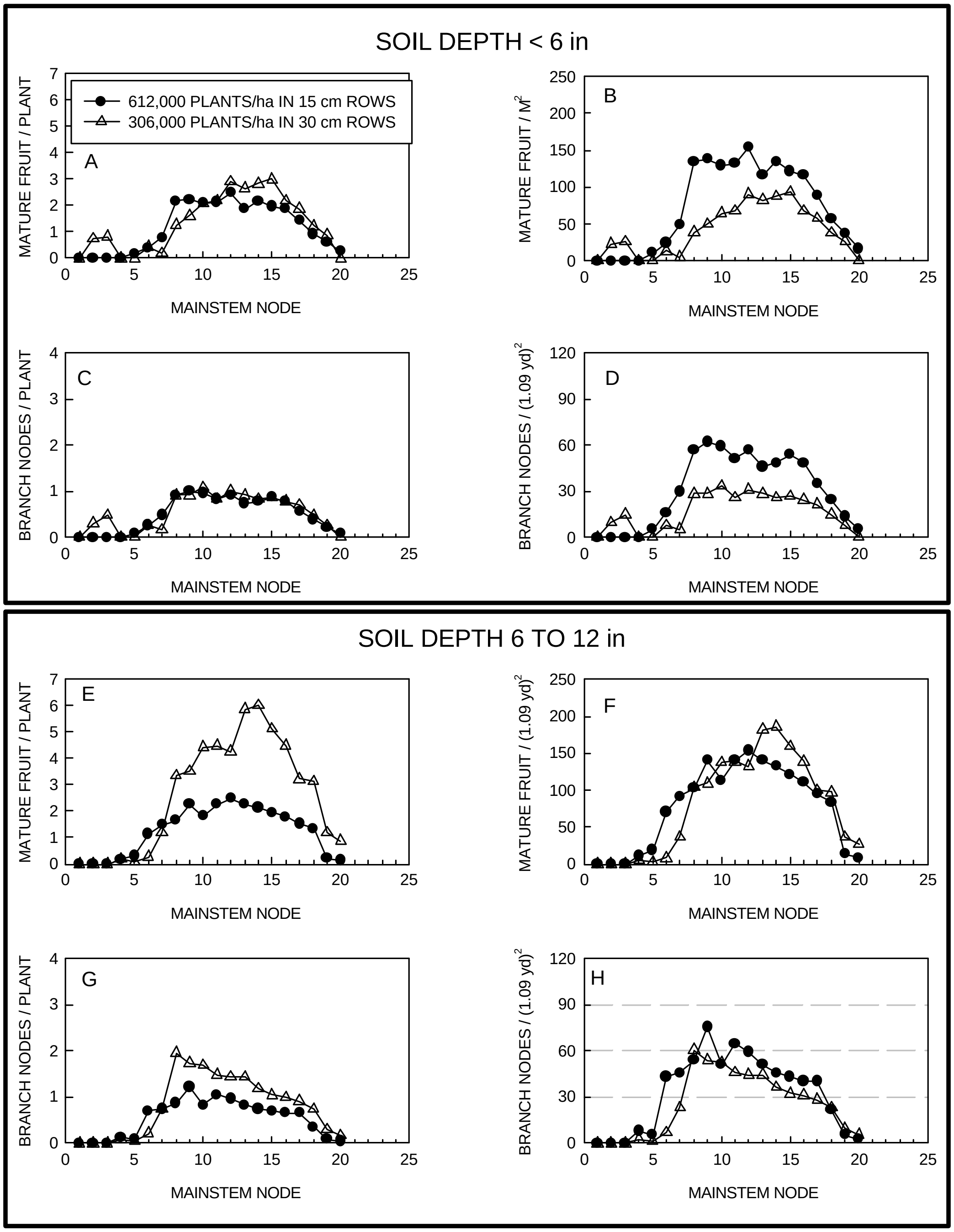


Fig. 2. Plant branching and fruiting response to varying soil rooting depths for two row spacings on a per plant and for an area basis. A thru D are for soil less than 6 in deep while E thru H are for soil 6 to 12 in deep.

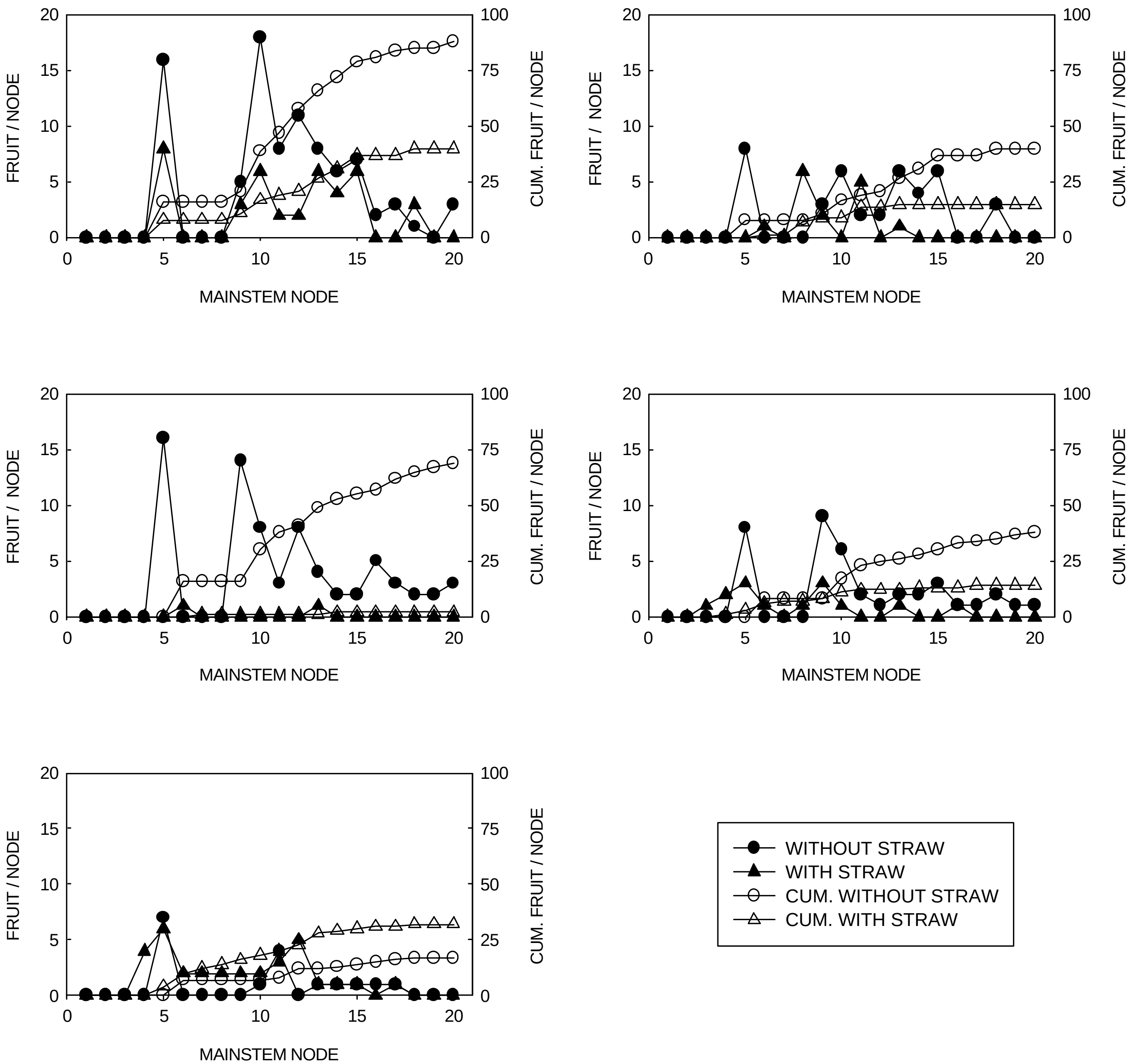


Fig. 3. Fruit classes versus mainstem node for soybeans grown with and without wheat straw residue. A, B, C, D, and E are for fruit classification of R2, R3, R4, R5, and R6, resp.

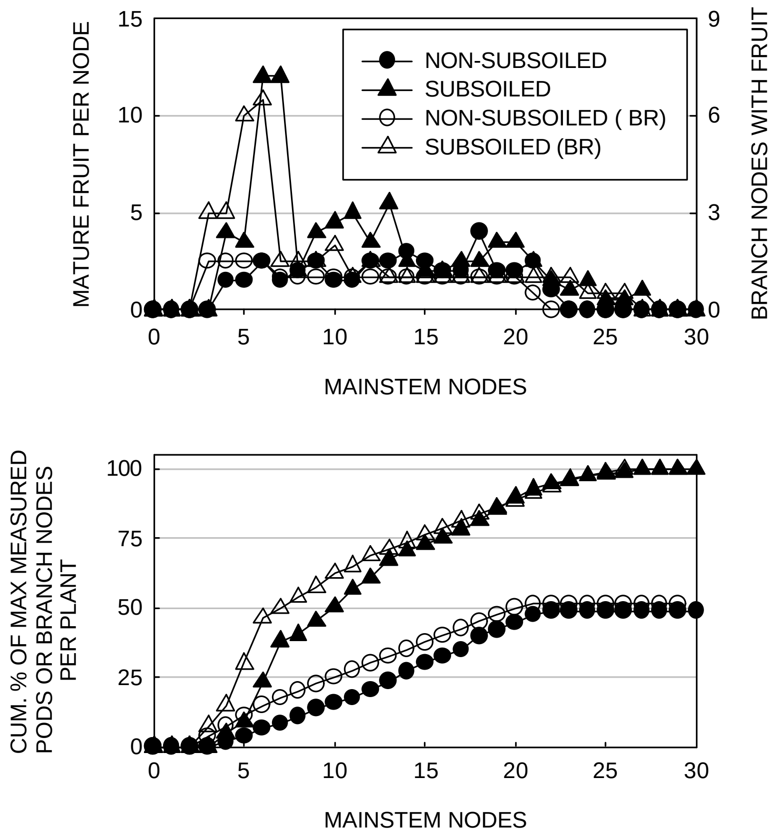


Fig. 4. Mature fruit (A), branch nodes (A), and cumulative percent of maximum fruits and pods per plant (B) versus mainstem node for in-the-row subsoiling and conventional planting.

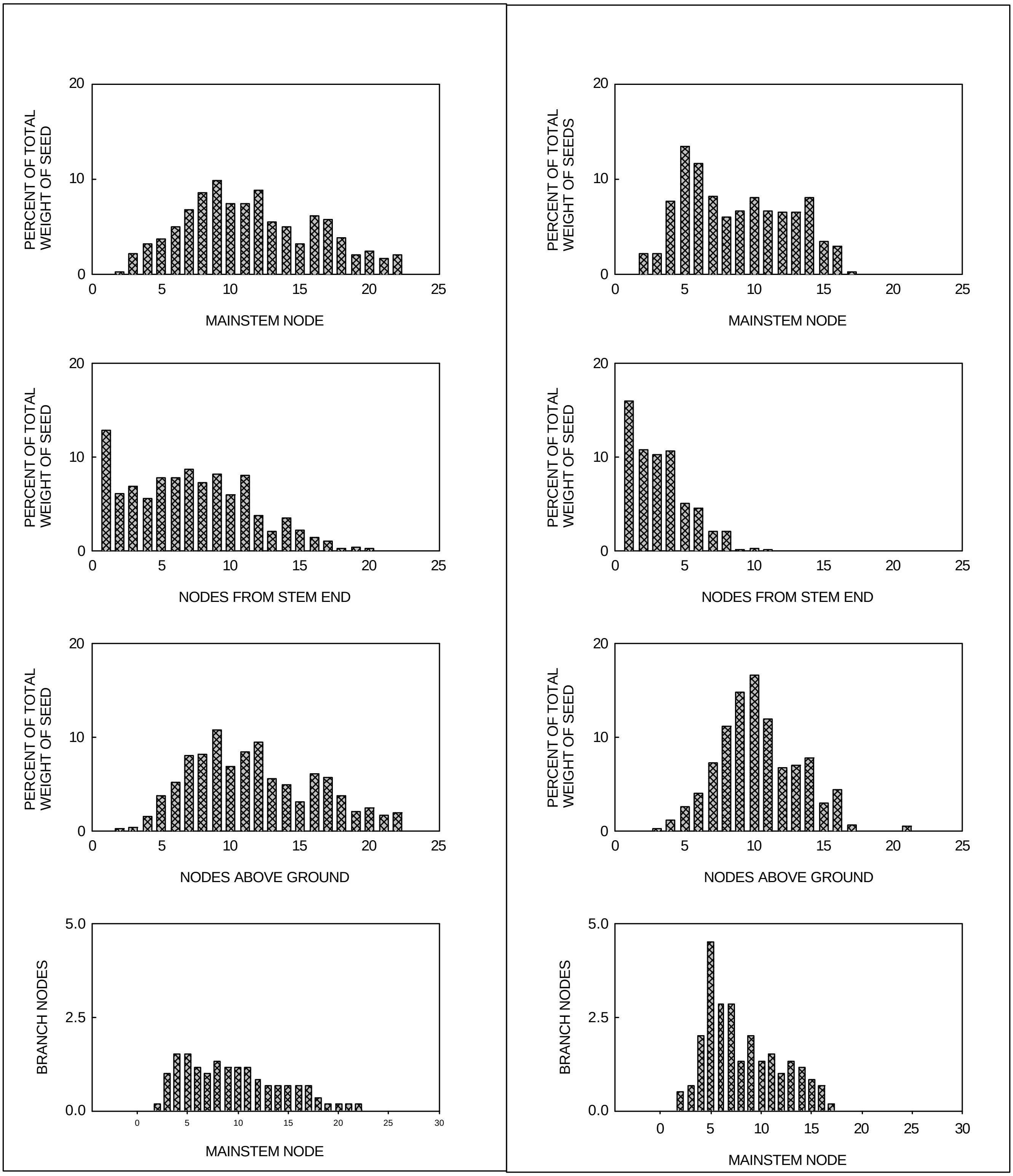


Fig. 5. Comparison of morphological characteristics for an indeterminate ('Williams 82') and a determinant ('Hutcheson') cultivar. Percent seed weight versus mainstem node (A and B), nodes-from-stem-end (C and D), and nodes-above-ground (E and F). Branch nodes versus mainstem nodes (G and H).

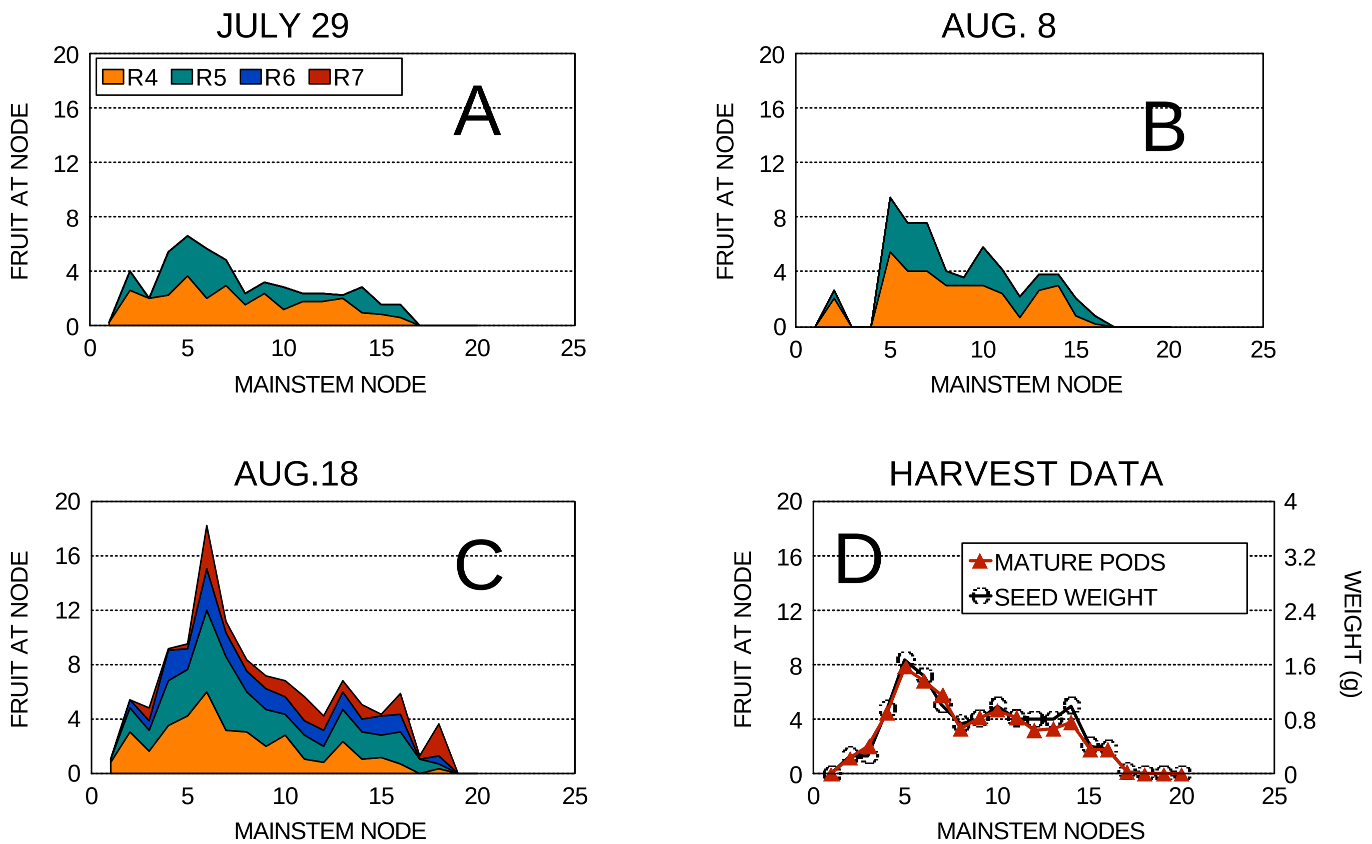


Fig. 6. Temporal progression of fruit toward maturity and at harvest. A, B, and C are stacked areas of R2, R3, R4, R5, and R6 fruit at the indicated dates. D is a line graph of fruit number and seed weight at harvest.

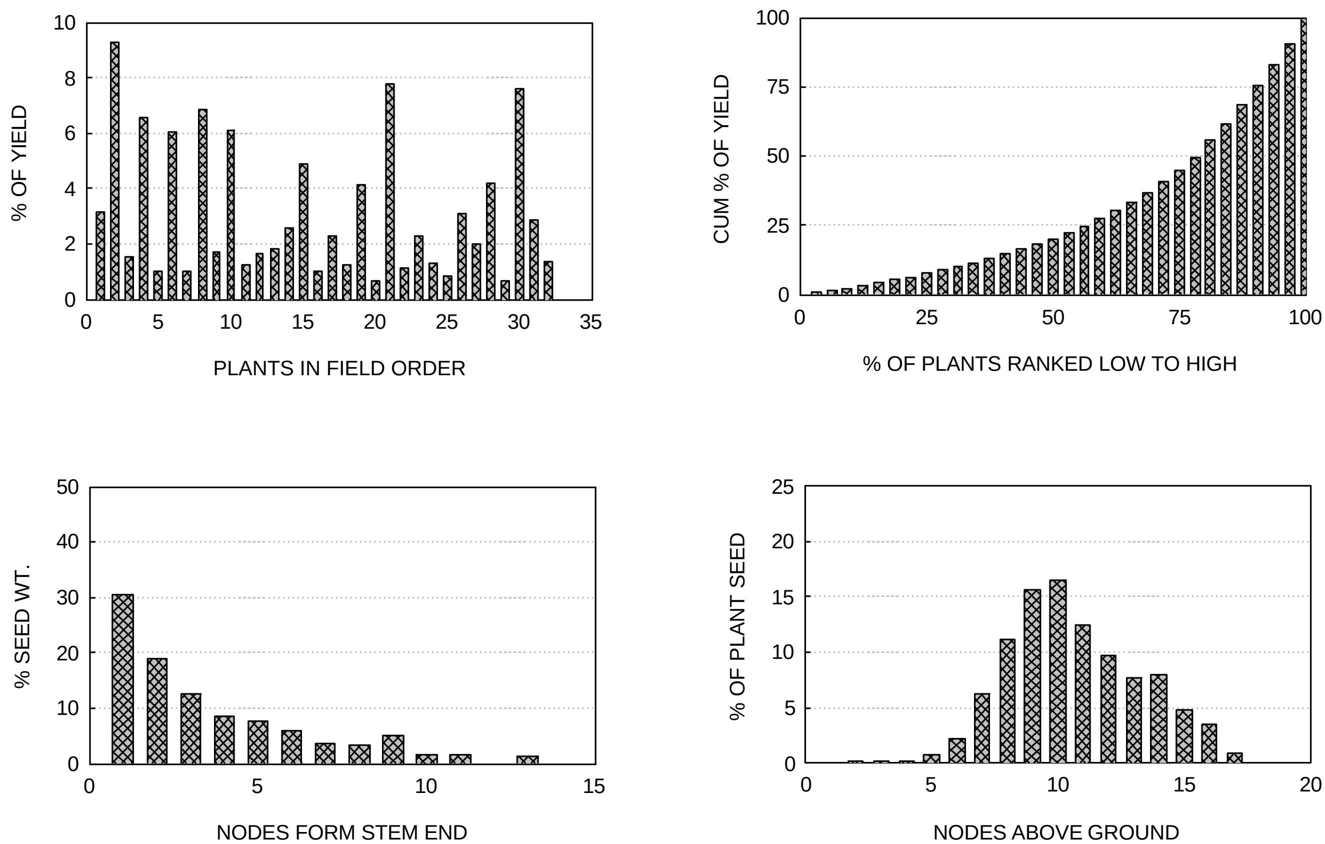


Fig. 7. Simple population characteristics of 'Manokin' soybean for locational effects on yield (A), cumulative yield (B), percent seed yield as a function of node-from-stem-end (C), and percent seed yield as a function of node-above-ground.

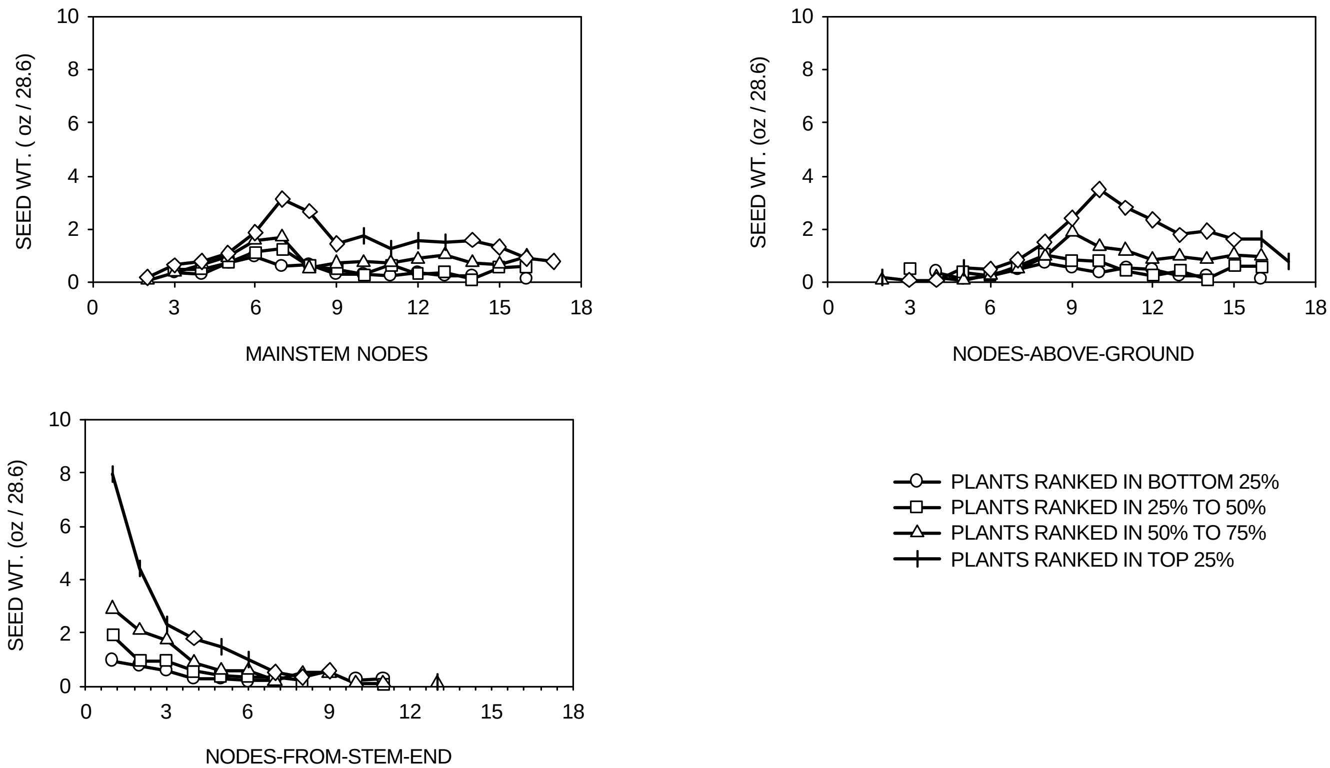


Fig. 8. Seed weight distribution at mainstem nodes (A), nodes-above-ground (B), and nodes-from-stem-end (C) for low to high yielding quartiles of 'Manokin' soybean.

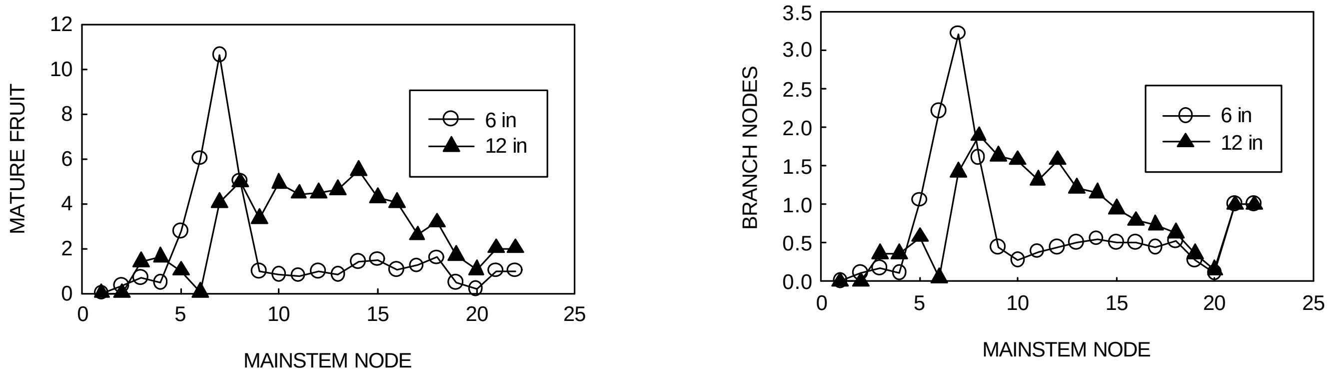


Fig. 9. Fruiting (A) and plant branching (B) response to lodging.

VARIETY RESPONSE OF STRIP-TILL COTTON INTO WINTER COVER CROPS AT GAINESVILLE, FLORIDA

R.N. Gallaher[1]

AUTHOR: [1]Professor of Agronomy, PO Box 110730, Agronomy Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611-0730; E-mail: rng@gnv.ifas.ufl.edu.. No endorsements or registrations implied herein.
REFERENCE: J. E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*. Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

ABSTRACT. Upland cotton (*Gossipium hirsutum*) is an old crop that is becoming increasingly new and important to Florida farmers. The objective of this research was to determine best yielding cotton varieties in north Florida using strip-till management in three different cropping systems. Fourteen varieties were tested in 1998 in three identical randomized complete block experiments that differed only in location and cropping history on the University of Florida Green Acres Agronomy Field Research Laboratory near Gainesville, Florida. Experiment one had a history of growing ‘Hairy’ vetch (*Vicia villosa*) as the winter crop every year for the past 22 years. Experiment two had a history of growing ‘Dixie Reseeding’ crimson clover (*Trifolium incarnatum*) as the winter crop every year for the past 15 years. Experiment three had a history of growing ‘Wren’s Abruzzi’ rye (*Secale cereale*) as the winter crop every year for the past 15 years. Yields following rye were as high as 2.75 bales lint cotton/acre. Most glyphosate tolerant varieties ranked in the top group for yield. Yields among varieties varied from 90 % to 120 % depending upon the cropping system. Seed cotton ranged from a low of 43 % to a high of 49 % lint. Percent lint varied widely suggesting that care should be given to this adjustment for accurate determination of yield among varieties. Lint yield was positively correlated with N concentration in diagnostic leaf and petiole, r = 0.91 and r = 0.71, respectively. The suggested N sufficiency range in diagnostic leaves, under these conditions, is suggested to be between 4.50 % and 5.00 %.

INTRODUCTION

Upland cotton (*Gossypium hirsutum* L.) acreage has significantly increased in Florida over the past 20 years. This has helped to offset the loss in acreage and farm income from other field crops such as soybean (*Glycine max* L. Merr) and corn (*Zea mays* L.) (Gallaher and Brecke, 1999). Data show that cotton is an important crop in Florida, contributing to the stability of farm income and newly developed glyphosate resistant varieties are likely to help improve management, yields and profits for growers (Brecke, 1997). Utilizing strip-till management has proven highly successful for many row crops which provide numerous conservation benefits (Gallaher and Hawf, 1997). For these reasons it is important to determine management requirements, cropping systems and best performing varieties for strip-till cotton, under north Florida conditions. Therefore the objective of this research was to determine best yielding varieties for strip-till cotton in three different cropping systems.

MATERIALS AND METHODS

Three identical experiments were conducted in 1998 under similar soil type and at the same location. However, each experimental site had a different cropping history. Experiments were conducted at the "Green Acres Agronomy Field Research Laboratory " 12 miles west of Gainesville, Florida. Experiment one had a history of continually growing ‘Hairy’ vetch (*Vicia villosa* L.) as the winter crop every year for the past 22 years. Experiment two had a history of continually growing ‘Dixie Reseeding’ crimson clover (*Trifolium incarnatum* L.) as the winter crop every year for the past 15 years. Experiment three had a history of continually growing ‘Wren’s Abruzzi’ rye (*Secale cereale* L.) as the winter crop every year for the past 15 years.

Soil type was an Arredondo fine sand (Sandy Siliceous Thermic Paleudult) (Anonymous, 1994), and consists of 95 % to 97 % sand and only 3 % to 5 % silt plus clay. Cotton was strip-till (Brown-Harden in-row subsoil no-till planter) planted directly into the residue of each of the previous winter crops on 18 May 1998, at a rate of 6 seed per linear foot of row. Seed hoppers were John Deere Flexie 71 units.

Experiments were in randomized complete block designs, replicated five times in 30 inch wide rows, two rows per plot and 20 feet long rows. Two border rows were planted on each side of the varieties being tested. Treatments consisted of 14 cotton varieties (Table 1).

A preemergence application of 0.75 lb a.i. Prowl (plendimethalin), 1.0 lb a.i. Meturon (fluometuron), and 2 lb a.i. Roundup Ultra (glyphosate) was made on 20 May. Additional weed control included post direct application of

1.5 pints Gramoxone (paraquat)/acre two times, 2 July and again 10 July. A fertilizer blend was applied beside the row two times. The blend was 13-5-29-1-2.5 ($N-P_2O_5-K_2O-Mg-S$) and 460 lb/acre was applied on 3 June and 460 pounds/acre was applied a second time on 6 July. Insecticides included the application of labeled rates of Lannate (methomyl) and Baythoid (cyfluthrin) four times on 10 July, 4 August, 14 August, and 24 August. Irrigation was by stationary guns to ensure a minimum of 1.25 acre inches of water if rainfall was not sufficient from 11 July to 20 August. Labeled rate of Harvade-5F (dimethipin) was applied on 2 October. In addition 1.5 pints Gramoxone/acre was applied to complete defoliation on 6 October. Both rows of cotton were hand picked beginning 12 October.

Each plot of harvested cotton was stored in a metal building for one month to allow equilibration before being weighed. Approximately ½ pound subsamples were ginned using a laboratory cotton gin (Porter Morrison & Sons 20 saw laboratory cotton gin, Dennis Mfg. Co., Inc.), lint and seed weighed, dried in a forced air oven at 70 C and reweighed. This procedure allowed calculation of percent dry matter, percent lint, and adjustment of varieties to the same moisture for accurate yield comparisons.

Diagnostic leaves and petioles were collected from the youngest mature leaves on 4 August during the active bloom and boll set stage in order to assess sufficiency levels of N (Jones, 1974). A total of 20 leaves and petioles were collected per variety, on three replications per experiment. Leaves and petioles were washed (Gallaher, 1996), dried at 70 C in a forced air oven, ground to pass a 2 mm stainless steel screen and stored for microKjeldahl N analysis. All ground samples were redried prior to weighing for analysis. A 100 mg sample was weighed into Pyrex test tubes and digested (digest mix was 3.2 g 90% K_2SO_4: 10% $CuSO_4$ plus 10 ml of concentrated H_2SO_4) (Gallaher, et al., 1975). Nitrogen was determined colorimetrically by autoanalysis.

Field and laboratory data was recorded in QUATTRO PRO (Anonymous, 1987) spreadsheets for tabulation, transformations, and making ASCII files. Analysis of variance was completed for a randomized complete block design using MSTAT statistical software (Anonymous, 1985). If yield and related data were significant among varieties at the 0.05 level of probability means were separated using Duncan's New Multiple Range Test. If N concentration data was significant at the 0.10 level of probability means were separated using Duncan's New Multiple Range Test.

RESULTS AND DISCUSSION

Yield

Some cotton varieties provided yield as much as twice that of others (Table 1). Data show that variety selection in north Florida will be extremely important to the economy of cotton farmers. Assuming lint cotton to be 480 pounds/bale, then lint yield was as high as 2.75 bales/acre (Table 1). Glyphosate tolerant varieties of cotton were very competitive and four of the six glyphosate tolerant varieties were among the highest yielding (Table 1).

Data also show that cropping history is important in the production of cotton. Although statistical comparisons are not mathmatically legal, it is important to point out that all three studies were conducted within 50 yards of each other, on the same soil type and with identical management. The three sites differed only in cropping history as described earlier. It can be noted that cotton following a history of rye as the winter crop provided the highest yield values, and there appears to be a slight advantage of following crimson clover over hairy vetch (Table 1). Others have reported similar yield advantage for cotton following a wheat (*Triticum aestivum* L.) grass crop in succession compared to a succession with hairy vetch (Holman, et al., 1997). Previous research has shown cropping history on these sites to have differential nematode infestations, with the two legume sites being highly infested in root-knot nematode compared to the rye site (McSorley and Gallaher, 1997). However, there is no indication that root-knot nematode is a problem for these cotton varieties. On the other hand some unknown disease and other problems may have increased in the legume sites compared to the grass site that may explain why cotton did better following a long term history of growing winter rye.

Varieties differed in percent lint (Table 2). On a air dried equilibrated basis percent lint ranged from about 42% to over 47%. On a dry matter basis differences among varieties generally maintained their position but ranged from a low of about 43 % to a high of over 49 %. Based on communication with cotton research colleagues, these values are much higher than what is generally used to calculate lint yield from seed cotton yield. Some researchers apparently use a figure of about 36 % to 38% lint to calculate lint yield in variety trials. Based on my research reported here, using such a factor among varieties would result in erroneous reporting and erroneous differences among varieties. Generally, it appears that the highest lint yielding varieties had a lower percent lint compared to the low lint yielding varieties (Table 2).

Generally varieties maintained their ranking in lint and seed yield when based on a specific dry matter (Table 3) when compared to air dried seed cotton yield (Table 1). However, on an equal dry matter basis five of the six glyphosate tolerant varieties were in the top lint yielding group, while four of the six were in the top seed yielding group (Table 3).

Nitrogen Analysis

Nitrogen concentrations in diagnostic leaves and petioles were consistently higher for cotton following rye (Table 4). Among varieties following rye there was a positive correlation between lint yield (Table 3) and both leaf N and petiole N ($r = 0.84$ for leaf; $r = 0.74$ for petiole) (Table 4). When lint yield for all varieties and all three locations were correlated with leaf N concentration, a positive correlation of 0.91 was found. For these same yield data and petiole N the correlation coefficient was 0.71. All correlations were positive between leaf N and yield in all three experiments or combinations of all experiments. Because highest lint yields were positively correlated with leaf N concentration it can be assumed that N values of 4.50% to 5.00% are needed under conditions of these studies, especially for some of the glyphosate tolerant varieties, in order to maximize yield. This is in contrast to lower values suggested by Jones (1974) who reported that upper mature leaves on vegetative stems prior to or at first bloom or when first squares appear should have a sufficiency range for N of between 3.75 % and 4.50 %. Because N concentrations were much lower than this range for cotton following a history of crimson clover or hairy vetch, it can be assumed that there may be some factor interfering with the absorption of N at these site. One could assume that the legume sites should have had more N available for cotton to absorb compared to the rye site. This is because there should be N available from the previous legume crop, as well as the same N fertilizer application made at all three sites.

ACKNOWLEDGMENTS

This research was partially funded by a grant from Cotton Incorporated. The author appreciates the assistance of Mr. Howard Palmer, Mr. Walter Davis, Mr. Jim Chichester, Mr. Scott Tubbs, and Ms. Jackie Greenwood in conducting this research. Appreciation is also extended to Dr. David L. Wright who provided seed he obtained from industry sources.

LITERATURE CITED

Anonymous. 1985. Users Guide to MSTAT, Version 4.0. Michigan State University, Lansing, MI.

Anonymous. 1987. QUATTRO PRO, Ver. 4.0. A Spreadsheet Software Program, Scotts Valley, CA: Borland International, Inc.

Anonymous. 1994. Official soil series description for the Arredondo series. United State Government Printing Office, Washington, DC.

Brecke, B.J. 1997. Weed management in no-till Roundup tolerant soybean and cotton. pp. 233-237. *In* R.N. Gallaher and R. McSorley (eds.). Proceedings of the 20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Special Series SS-AGR-60, University of Florida, Gainesville, FL.

Gallaher, R.N., C.O. Weldon, and J.G. Futral. 1975. An aluminum block digester for plant and soil analysis. Soil Sci.Soc. Amer. Proc. 39:803-806.

Gallaher, R.N. 1995. Comparison of Zn Nutritional spray treatments for citrus leaf Zn adsorption and absorption. Agronomy Research Report AY-95-02. Agronomy Dept. IFAS, Univ. of Florida, Gainesville, FL.

Gallaher, R.N., and B.J. Brecke. 1999. Base paper for field crops. University of Florida, IFAS Strategic Planning Conference, FLORIDA FIRST, May 20-21, 1999, Safety Harbor Resort and Spa, Safety Harbor, Florida. IN PRESS.

Gallaher, R.N., and L. Hawf. 1997. Role of conservation tillage in production of a wholesome food supply. pp. 23-27. *In* R.N. Gallaher and R. McSorley (eds.). Proceedings of the 20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Special Series SS-AGR-60, University of Florida, Gainesville, FL.

Holman, E.M., A.B. Coco, and R.L. Hutchinson. 1997. Cover crop and tillage for cotton production on alluvial soils of northeast Louisiana. pp. 208-110. *In* R.N. Gallaher and R. McSorley (eds.). Proceedings of the 20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Special Series SS-AGR-60, University of Florida, Gainesville, FL.

Jones, J.B., Jr.,. 1974. Plant Analysis Handbook for Georgia. Bulletin 735. Cooperative Extension Service, Univ. of Georgia College of Agriculture, Athens, GA.

McSorley, R., and R.N. Gallaher. 1997. Nematode population levels on vegetable crops following two winter crops. pp. 96-99. *In* R.N. Gallaher and R. McSorley (eds.). Proceedings of the 20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Special Series SS-AGR-60, University of Florida, Gainesville, FL

Table 1. Three-week Equilibrated Field Weight Cotton Yield for Varieties Strip-tilled and Double Cropped in 1998 at Gainesville, Florida.

Cotton Variety	Rye	Clover	Vetch
--Pounds Seed Cotton/Acre----------------------------------			
Deltapine DP 4.58 BR	3076 a	2416 a	1251 ab
\Deltapine DP 5415 RR	2850 ab	2257 ab	1758 a
Deltapine DP 5690 RR	2802 ab	2456 a	1772 a
Sure-Grow 501	2690 abc	2196 abc	1681 a
Deltapine DP 655 BG/RR	2644 abcd	1297 e	1661 a
Paymaster H 1560	2524 abcde	2054 abcd	1772 a
Sure-Grow 125	2588 bcde	1913 bcde	1479 a
Stoneville LA 887	2463 bcde	1679 bcde	1483 a
Paymaster PM 1220 BG/RR	2452 bcde	2241 ab	1477 a
Paymaster PM 1220 RR	2281 bcde	2107 abcd	1573 a
Deltapine Nucoton 33 B	2185 cde	1576 cde	1549 a
Stoneville ST 47	2082 de	1508 de	1528 a
Stoneville BXN 47	2033 ef	1815 abcde	1697 a
Stoneville ST 373	550 f	1485 de	0744 b
---Pounds Lint Cotton/Acre--			
Deltapine DP 4.58 BR	1317 a	1051 a	0545 ab
DeltapineDP 5415 RR	1188 ab	0989 ab	0743 a
Deltapine DP 5690 RR	1185 ab	1036 a	0747 a
Sure-Grow 501	1157 abc	0903 abcd	0729 a
Deltapine DP 655 BG/RR	1146 abd	0548 e	0720 a
Paymaster H 1506	1073 abc	0874 abcd	0744 a
Sure-grow 125	1047 bc	0823 abcd	0631 a
Stoneville LA 887	1032 bc	0720 bcd	0646 a
Paymaster PM 1220 BG/RR	1091 abc	0946 abc	0634 a
Paymaster PM 1220 RR	1022 bc	0901 abcd	0697 a
Deltapine Nucotn 33 B	0922 c	0678 cde	0644 a
Stoneville ST 47	0983 bc	0691 cde	0689 a
Stoneville BXN 47	0952 bc	0828 abcd	0759 a
Stoneville ST 373	0673 d	0648 d	0333 b

Values in columns not followed by the same letter are significantly different at the 0.05 level of probability according to Duncan's New Multiple Range Test. Lint was determined from ginned subsamples from each plot.

Table 2. Percent Lint in Seed Cotton for Varieties Strip-tilled and Double Cropped in 1998 at Gainesville, Florida.

	Rye	Clover	Vetch
Percent Lint Based on Three Week Equilibration			
Deltapine DP 458 BR	42.8 cdef	43.5 b	43.6 abcd
Deltapine DP 5415 RR	41.7 g	43.8 b	42.3 de
Deltapine DP 5690 RR	42.3 defg	42.2 bc	42.2 de
Sure-Grow 501	43.0 cde	41.1 c	43.4 c

Deltapine DP 655 BG/RR	43.2 cd	42.3 c	43.4 abcd`
Paymaster H 1560	42.5 cdefg	42.6 bc	42.0 de
Sure-Grow 125	42.1 efg	43.0 b	42.7 cde
Stoneville LA 887	41.9 fg	42.9 b	43.5 abcd
Paymaster PM 1220 BG/RR	44.5 b	42.2 b	43.0 cde
Paymaster PM 1220 RR	44.8 b	42.8 b	44.3 abc
Deltapine Nucotn 33 B	42.2 defg	43.0 b	41.6 e
Stoneville ST 47	47.2 a	45.8 a	45.1 a
Stoneville BXN 47	46.8 a	45.6 a	44.7 ab
Stoneville ST 373	43.4 c	43.6 b	44.8 ab
	Percent Lint Based on Dry Matter		
Deltapine DP 458 BR	44.4 cde	44.6 cd	43.5 abcd
Deltapine DP 5415 RR	43.3 f	44.5 cd	41.9 defg
Deltapine DP 5690 RR	43.9 def	43.1 d	42.2 cdefg
Sure-Grow 501	44.6 cd	45.3 bc	43.1 abcdef
Deltapine DP 655 BG/RR	44.6 cd	43.1 d	41.6 efg
Paymaster H 1560	44.3 def	43.9 cd	41.4 fg
Sure-Grow 125	44.0 def	44.0 cd	42.4 bcdefg
Stoneville LA 887	43.6 ef	44.1 cd	41.3 abcde
Paymaster PM 1220 BG/RR	46. b	43.2 d	42.6 abcdefg
Paymaster PM 1220 RR	46.4 b	43.5 d	43.8 abc
Deltapine Nucotn 33 B	44.0 def	44.1 cd	41.3 g
Stoneville ST 47	49.4 a	46.4 a	44.3 a
Stoneville BXN 47	49.1 a	46.9 a	44.4 a
Stoneville ST 373	45.3 c	44.7 cd	44.1 ab

Values in columns not followed by the same letter are significantly different at the 0.05 level of probability according to Duncan's New Multiple Range Test. Percent line was determined from grinned subsamples for each plot.

Table 3. Moisture Adjusted Lint and Seed Yield of Cotton for Varieties Strip-tilled and Double Cropped in 1998 at Gainesville, Florida.

Cotton Variety	Rye	Clover	Vetch
	----------------Lint Yield at 93.5% Dry Matter, Pounds/Acre-----------		
Deltapine DP 458 BR	1346 a	1038 a	0542 ab
Deltapine DP 5415 RR	1211 ab	0974 ab	0738 a
Deltapine DP 5690 RR	1212 ab	1021 a	0740 a
Sure-Grow 501	1179 ab	0891 abcd	0721 a
Deltapine DP 655 BG/RR	1174 ab	0544 e	0717 a
Paymaster H 1560	1096 ab	0867 abcd	0738 a
Sure-Grow 125	1071 b	0812 abcd	0628 a
Stoneville LA 887	1055 b	0710 bcde	0641 a
Paymaster PM 1220 BG/RR	1119 ab	0935 abc	0633 a
Paymaster PM 1220 RR	1047 b	0889 abcd	0690 a
Deltapine Nucotn 33 B	0945 b	0667 cde	0641 a
Stoneville ST 47	1006 b	0680 cde	0681 a
Stoneville BXN 47	0974 b	0819 abcd	0752 a
Stoneville ST 373	0688 c	0637 de	0331 b
	------------- Seed Yield at 92% Dry Matter, Pounds/Acre --------------		
Deltapine DP 458 BR	1758 a	1334 a	0743 ab
Deltapine DP 5415 RR	1664 ab	1242 ab	1052 a
Deltapine DP 5690 RR	1622 ab	1390 a	1065 a
Sure-Grow 501	1530 abc	1267 ab	0986 a
Deltapine DP 655 BG/RR	1509 abc	0734 e	0983 a
Paymaster H 1560	1458 abc	1154 abcd	1067 a
Sure-Grow 125	1436 bc	1064 abcde	0881 a
Stoneville LA 887	1433 bc	0938 bcde	0870 a
Paymaster PM 1220 BG/RR	1362 bcd	1270 ab	0878 a
Paymaster PM 1220 RR	1261 cd	1181 abc	0913 a
Deltapine Nucotn 33 B	1266 cd	0876 cde	0942 a
Stoneville ST 47	1099 de	0796 e	0873 a
Stoneville BXN 47	1077 de	0963 bcde	0976 a
Stoneville ST 373	0876 e	0817 de	0428 b

Values in columns not followed by the same letter are significantly different at the 0.05 level of probability according to Duncan's new Multiple Range Test. Percent lint was determined from grinned subsamples for each plot.

Table 4. Nitrogen Concentration in Diagnostic Leaves and Petioles of Cotton for Varieties Strip-tilled and Double Cropped in 1998 at Gainesville, Florida.

Cotton Variety	Rye	Clover	Vetch
		--------Leaf N, %--------	
Deltapine DP 458 BR	4.98 ab	4.10 ab	3.81 abc
Deltapine DP 5415 RR	5.01 a	3.70 abc	3.93 abc
Deltapine DP 5690 RR	4.60 abcde	3.72 abc	3.95 abc
Sure-Grow 501	4.70 abcd	4.10 ab	4.17 a
Deltapine DP 655 BG/RR	4.66 abcd	3.95 abc	4.06 ab
Paymaster H 1560	4.45 bcde	4.16 a	4.19 a
Sure-Grow 125	4.43 bcde	3.75 abc	3.59 bc
Stoneville LA 887	4.30 cde	3.64 bc	3.55 c
Paymaster PM 1220 BG/RR	4.63 abcde	4.15 a	3.79 abc
Paymaster PM 1220 RR	4.77 abc	4.16 a	4.13 a
Deltapine Nucotn 33 B	4.20 de	3.91 abc	4.09 a
Stoneville ST 47	4.68 abcd	3.66 bc	3.72 abc
Stoneville BXN 47	4.21 de	3.90 abc	4.14 a
Stoneville ST 373	4.10 e	3.63 c	3.73 abc
		-------- Petiole N, % --------	
Deltapine DP 458 BR	2.12 a	1.36 ab	1.26 bcde
Deltapine DP 5415 RR	1.83 abcd	1.18 b	1.33 bcde
Deltapine DP 5690 RR	2.05 a	1.41 ab	1.48 bc
Sure-Grow 501	1.59 bcde	1.34 ab	1.37 bcde
Deltapine DP 655 BG/RR	1.89 abc	1.54 ab	1.51 bc
Paymaster H 1560	1.85 abcd	1.52 ab	1.89 a
Sure-Grow 125	1.92 ab	1.19 ab 0	1.08 e
Stoneville LA 887	1.79 abcde	1.23 ab	1.21 cde
Paymaster PM 1220 BG/RR	1.52 bcde	1.45 ab	1.10 e
Paymaster PM 1220 RR	1.77 abcde	1.55 a	1.34 bcde
Deltapine Nucotn 33 B	1.46 cde	1.47 ab	1.56 ab
Stoneville ST 47	1.84 abcd	1.22 ab	1.26 bcde
Stoneville BXN 47	1.44 de	1.48 ab	1.45 bcd
Stoneville ST 373	1.36 e	1.32 ab	1.14 de

Values in columns not followed by the same letter are significantly different at the 0.05 level of probability according to Duncan's New Multiple Range Test.

ON-FARM RESEARCH AND DEMONSTRATION USING CONSERVATION-TILLAGE IN GEORGIA

Glen Harris[1], Rick Reed[2], Randy Roberts, Andy Page, Daniel Lavender, Mark Van Waldner and Ben Tucker

AUTHORS: [1]Assistant Professor, Crop and Soil Sciences Department, University of Georgia, RDC Building, P.O. Box 1209, Tifton, Georgia, 31793; [2]University of Georgia, Cooperative Extension Service, Douglas, GA 31533. Corresponding author Glen Harris, Email :gharris@arches.uga.edu
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTRODUCTION

Conservation-tillage in the Southeastern U.S. has the potential to save soil from erosion, increase much-needed soil organic matter levels, and most importantly, save growers money in terms of fuel, labor and trips across the field. Despite these potential benefits, it is estimated that only 15% of the row crops grown in South Georgia (a total of approximately 2.5 million acres of cotton, peanut, corn, and soybean) are grown using conservation-tillage practices. The most common form of conservation-tillage used for row crops in South Georgia is strip-till, where a subsoil shank is used and a narrow seed bed (anywhere from 6 to 18 inches wide) is prepared. Strict no-till (with or without some subsoil tillage such as a paraplow) is being investigated but is currently rarely used. Most experienced strip-till growers plant into a killed winter cover crop such as rye or wheat. Some cotton and soybeans are strip-tilled after wheat for grain. Legumes such as crimson clover are also used, but currently to a much lesser extent. In addition, new strip-till growers often plant summer crops into stubble of the previous summer crop (usually cotton or corn) or winter weeds. The main barriers to adoption of conservation tillage include the cost of purchasing new equipment and concerns about 1) weed control, 2) controlling the winter cover crop in spring (especially rye), and 3) trying something new and different.

Coffee County, Georgia, located approximately 45 miles east of Tifton, is a large agricultural county and is currently viewed as a leader in the area of conservation-tillage. Attempts to begin a conservation-tillage program in the early 1980's in Coffee County actually failed due to lack of suitable equipment and management knowledge. In 1990, the concept of conservation-tillage was revisited, especially with vegetables, with the main goals of decreasing soil erosion and increasing alternative habitats for beneficial insects. As a result, conservation-tillage increased in Coffee county from 15 acres in 1991 to over 25,000 acres in 1996.

As conservation-tillage acres have increased in Coffee County (as well as other counties), additional questions by growers needed to be addressed. Which cover crops are best and how much residue can they produce? When is the best time in the fall to plant winter cover crops? How much nitrogen should be used on cotton following legume or small grain cover crops? In fall 1995, on-farm demonstrations and research studies were started in Coffee County to address these questions. A local grower, Tommie Dorminey, designated a 6-acre block of land (under solid-set irrigation) for conservation-tillage demonstrations and research. Since then, studies have expanded onto other fields on the Dorminey farm and also into other counties. The demonstrations and research reported here were conducted by a team consisting of UGA extension specialists and county agents, as well as personnel from USDA-NRCS.

OBJECTIVES

The overall objective of the on-farm demonstration and research studies reported here was to gain a better understanding of conservation-tillage systems in general. Specific objectives, largely governed by grower interest, included 1) conducting a preliminary screening of cover crops, measuring biomass and nitrogen production, and then observing the growth of different summer crops to follow, 2) investigating the effect of timing of planting winter cover crops in the fall on biomass and nitrogen production, and 3) determining the proper nitrogen rate for cotton planted strip-till after different small grain and legume winter cover crops.

MATERIALS AND METHODS

Cover Crop Screening

Ten different small grain and legume cover crops were planted on December 5, 1995, on a Tifton loamy sand on the farm of Tommie Dorminey in Coffee County. Cover crops included in the screening were 'AU Robin' crimson clover, 'Tibbee' crimson clover, big berseem clover, ball clover, 'Cherokee' red clover, 'AU Early Cover' vetch, 'Cahaba' white vetch, rye, and blue lupine. Plot size was 6 feet wide by approximately 800 feet long. Plots were seeded using a modified broadcast turfgrass seeder with rolling baskets. Legumes were inoculated with proper species and at the recommended rate. Seeding rates as recommended by the UGA Extension Service were used. All treatments were replicated four times. Irrigation was used to establish the new seedings and sparingly over the winter.

On April 8, 1996, all cover crops were sampled to estimate biomass and nitrogen production (above- and below-ground). Two areas in each plot measuring 14 inches by 14 inches were sampled. Top growth was clipped at ground level and removed by hand, then dried, weighed, and analyzed for nitrogen using a standard Kjeldahl procedure. Crowns and roots to a depth of approximately 6 inches were then removed from the same sampling areas. The roots/crowns were removed using a flat-faced garden shovel and initially shaken by hand to remove excess soil. The roots/crowns were then further cleaned by washing with a garden hose under pressure. Roots/crowns were then dried, weighed and analyzed for nitrogen content like the shoots.

Immediately after sampling for biomass, the cover crops were killed or burned down with a herbicide mixture of Gramaxone and Karmex. Two weeks later, cotton, corn, pearl millet, and grain sorghum were planted using strip-tillage, each on one of the four replications. Each summer crop was managed according to the grower and included using sidedress nitrogen on all four summer crops.

Timing of Planting Winter Cover Crops

In fall 1996, a study to examine the effect of planting date on winter cover crop biomass and nitrogen production was conducted using the same 6-acre block used for the cover crop screening study described above. The number of winter cover crops used was narrowed from ten to five based on observations in the screening study. ‘AU Robin’ crimson clover and ‘AU Early Cover’ vetch were chosen for their demonstrated earliness, ease of planting summer crops, and reseeding potential. ‘Cherokee’ red clover and ‘Cahaba’ white vetch were chosen based on their potential to maintain or suppress existing cotton nematode populations. Rye was also included for a small grain comparison and its demonstrated high biomass production. Planting dates for the five cover crops were October 2, October 23 and November 18, 1996. Plot size was increased in width to 12 feet, but reduced in length to 150 feet with 40 foot alleys. Irrigation was used again to assure establishment of the legumes but sparingly over the winter. Each planting date followed a different summer crop with October 2 following mostly pearl millet, October 23 following mostly corn and November 18 following mostly grain sorghum. Plots were established using a 10 foot wide no-till drill, recommended seeding rates, and inoculants. All planted on the October 2 date except the rye failed to get a stand. Therefore, all but the rye were reseeded on October 23, the same time as the second planting date.

On April 15, 1997, cover crops in all plots were sampled for biomass and nitrogen production (above- and below-ground) using the same methods described for the cover crop screening study. On May 1, 1997, cotton was planted using strip-tillage on all plots. Irrigation was only used when very dry.

Nitrogen Rates For Strip-Till Cotton

Three separate studies (one in 1997 and two in 1998) were conducted to determine the proper nitrogen rate for cotton following certain cover crops.

1997: In 1997, three different nitrogen rates (0, 30, and 60 lb N/a) were applied to cotton following cover crops in the October 23, 1996, planting date in the aforementioned study (on the same 6-acre block at Tommie Dorminey’s). Again, the five cover crops used were ‘AU Robin’ crimson clover, ‘AU Early Cover’ vetch, ‘Cherokee’ red clover, ‘AU Early Cover’ vetch, and rye. Plot size was 12 feet wide (4 rows) by 50 feet long. No preplant nitrogen fertilizer was applied. Nitrogen was applied by hand at sidedressing time (between first square and first bloom) using ammonium nitrate. Four replications were used. Cotton was harvested on November 4, 1997, using a 2-row picker. Cotton was gathered off the floor of the picker and placed in bags that were later weighed and sampled for turnout. All yields were then calculated and converted to a lb lint/a basis.

1998-1: In 1998, a study similar to the one described above was conducted on a different irrigated field, using larger plots and using the same cover crops except ‘Cherokee’ red clover, which was replaced by reseeded ‘AU Robin’ crimson clover. Soil type was predominately Tifton sandy loam with some Dothan loamy sand. ‘AU Robin’ crimson clover, ‘AU Early Cover’ vetch, ‘Cahaba’ white vetch, and rye were planted in fall 1997. Reseeded ‘AU Robin’ crimson clover was used as a fifth treatment and was already establishing itself when the other covers were planted. Cover crop plots size was 36 feet (12 rows) by approximately 700 feet long. All treatments were replicated four times. In spring 1998, all cover crops were sampled for above- and below-ground biomass and nitrogen production using methods described previously.

Cotton was established on all plots in May 1998. No preplant nitrogen fertilizer was applied. On June 29, 1998, sidedress N rates of 0, 30, and 60 lb N/a were applied as split plots on each cover crop using liquid nitrogen solution (UAN, 32% N). Each split plot measured 12 feet (4 rows) by the length of the field (approximately 700 feet long). On October 15, 1998, cotton was harvested from each plot using a 4-row picker and a boll buggy equipped with load cells and a scale. Cotton lint yields on a lb/a basis were then calculated using a common turnout factor of 38%.

1998-2: Another study of nitrogen rate for cotton following a cover crop was conducted in 1998 in Cook

County on the farm of Simmie King. 'AU Robin' crimson clover was established in a 10 acre dryland field on a Fuquay loamy sand in fall 1997. Biomass and nitrogen production by the cover crop was not measured but was estimated to be comparable to what had been observed in Coffee County – approximately 5 ton/a and 200 lb N/a between above- and below-ground biomass. Roundup Ready cotton was strip-tilled into the clover cover crop in spring 1998 and no herbicide used until spraying Roundup at the 4th leaf stage of the cotton. Sidedress N rates of 0, 30, and 60 were then applied at first square using liquid nitrogen solution (UAN 32%). Each plot measured 12 feet (4 rows) wide by approximately 600 feet long. The treatments were replicated 6 times. On October 14, 1998, cotton was harvested using a 4-row picker and weighed in a boll buggy equipped with scales. Cotton seed samples were taken from each plot and ginned for turnout. Yield was calculated on a lb lint/a basis.

RESULTS AND DISCUSSION

Cover Crop Screening

Adequate stands of all cover crops were initially established. Rye produced the most biomass with over 2 ton/a of above-ground dry matter and 1 ton/a of roots/crowns (Figure 1). 'AU Robin' crimson clover, big berseem clover, and 'Tibbee' crimson clover all produced around 2 ton/a of total biomass (above- and below-ground dry matter). Of these three, 'AU Robin' crimson clover had the most above-ground biomass and Big Berseem below-ground biomass. Arrowleaf clover, 'Cherokee' red clover, ball clover, and 'AU Early Cover' vetch all produced just under 2½ ton/a total biomass. Below-ground biomass for arrowleaf clover, 'Cherokee' red clover, and ball Clover accounted for about half of the total. In other words, there was as much biomass produced below-ground by these clovers as there was above-ground. 'AU Early Cover' vetch, on the other hand, produced very little below-ground biomass. This is characteristic of vetches, where root systems are small compared to above-ground growth. Vetch roots are also much finer than the other crops and thus harder to recover with the sampling method used, which may also have led to the lower below-ground biomass estimate. Both the 'Cahaba' white vetch and lupine cover crops appeared to have suffered sever cold damage and, in the case of lupine, winterkill. Again, initial stands were established, therefore cold weather in February and March seemed to limit total biomass production to less than a half ton/a for 'Cahaba' white vetch and essentially zero for lupine. An earlier planting date may have helped avoid this problem and using a different variety of lupine (maybe white instead of blue) may also have helped.

'AU Robin' crimson clover produced the most nitrogen in the total biomass with just under 160 lb N/a (Figure 2). Big berseem clover was a close second, producing around 150 lb/a total N. The distribution of nitrogen between above- and below-ground biomass was different between these two clover species, with 'AU Robin' crimson clover having most of the N in above-ground biomass, whereas almost half of the total N produced by big berseem was in below-ground biomass. 'Tibbee' crimson clover and 'AU Early Cover' vetch both produced around 120 lb total N/a with most in the above-ground biomass. Ball clover and 'Cherokee' red clover both produced just over 100 lb total N/a with 25% in below-ground biomass for ball and almost 50% for 'Cherokee' red. Arrowleaf clover and rye both produced around 90 lb total N/a. Almost half the N in arrowleaf was below-ground whereas a very small percentage of N was below-ground for rye. The high N production by rye was surprising and may be related to an application of 3 ton/a of poultry litter which all plots received before the cover crops were established. The plots thus were essentially fertilized with approximately 90 lb/a of available N which the legume cover crops did not take as much advantage of since they can fix their own nitrogen.

All cover crops were adequately burned down with the herbicide mixture with the exception of 'Cherokee' red clover. Lack of control on this legume cover crop was thought to be due to its growth habit (a late spring start continuing into the summer crop growing season).

All summer crops seemed to produce well regardless of which cover crop they followed. No establishment problems, problems during the growing season, or harvest problems were encountered.

Timing of Planting Winter Cover Crops

Failure to get a stand of the legume cover crops on the first planting date (October 2) may have been due to seeding depth being too deep or possibly allelopathic effects of the preceding summer crop (pearl millet). A combination of these two problems is also a possibility. Since all but the rye were replanted at the second planting date, there was very little visual difference in stands and biomass produced at the time of sampling the cover crops in the spring. There was also very little visual difference in cover crop biomass production between the first two planting dates and the last planting date (November 18). Therefore, biomass production is reported for the October 23 planting date only (Figure 3). Rye produced the most total (above plus below-ground) biomass at just over 8 ton/a. Again, about twice as much biomass was produced above-ground vs. below-ground for rye. Total biomass production by rye was significantly more than when planted late (December) in the cover crop screening the year before, when only about 3 ton/a total biomass were produced. For the legumes, both clovers and vetches produced about the same amount of total biomass, at about 8 ton/a. This was also more than when planted late in the screening study, when only about 1½ ton/a were produced. Distribution of biomass between above- and below-ground for the legumes was also similar to the screening study with ‘AU Robin’ crimson clover and ‘AU Early Cover’ vetch putting less growth below-ground compared to ‘Cherokee’ red clover and ‘Cahaba’ white vetch.

The cover crop biomass samples were not analyzed for nitrogen, therefore accurate estimates for nitrogen production can not be made. In fact, if nitrogen production is predicted by using the N content as analyzed the year before in the cover crop screening study, the estimates would range from 225 lb N/a for rye to 524 lb N/a for ‘Cahaba’ white vetch. These would obviously be an overestimation, especially for the legumes. It is likely that the N content of legumes in this study are lower due to the greater amount of biomass. Also, the greater amount of biomass in this study was likely due to being planted earlier.

Nitrogen Rates For Strip-Till Cotton

1997: There was no statistically significant cotton yield response to either cover crop or nitrogen rate measured in this study (Figure 4). Numerically, cotton yields following rye and ‘AU Robin’ crimson clover were greater than the other cover crops by at least 100 lb lint/a. Numerically, cotton yields also increased slightly with increasing N rates. Lack of statistical response could be attributed in part to variation in the study as indicated by a coefficient of variation of 21%. Some of this variation may have been due to nematode pressure that ranged from low to severe and was spatially random throughout the plots. Another possible explanation for the lack of response to cover crops or N rates was that the soil fertility level in the plots was very good, having a long history of fertilizing for high-yield vegetable production in addition to the poultry litter application made in 1995.

1998-1: There was no statistically significant cotton yield response to cover crops in this study; however, there was a statistically significant cotton yield increase with increasing rates of nitrogen (Figure 5). Reasons for the more positive response to N in this study compared to the 1997 study reported above include 1) different climatic conditions between years, and 2) lower overall soil fertility (again, no preplant N was used either year), and 3) fairly severe nematode damage throughout most of the plot area.

There was also no significant interaction between cover crop and N rate. This was unexpected and hard to explain. It was expected that the legume plots alone would have produced cotton yields similar to the small grain cover crop (rye) with some additional N. Also, yield increases with increasing N rates applied to the legume cover crops were not expected.

1998-2: In this study, there was a statistically significant cotton yield increase when going from the 0 to 30 lb/a sidedress N rate and following a good stand of ‘AU Robin’ crimson clover (Figure 6). However, there was no additional yield increase when going from the 30 to 60 lb N/a sidedress rate. Yield levels were also respectable for dryland cotton grown on a fairly sandy Coastal Plain soil. This indicates that the optimum N rate for cotton following a legume cover crop may be 30 lb N/a. Applying no sidedress N in this situation will sacrifice yield, and applying more than this rate may not be justified economically.

CONCLUSIONS

The overall objective of gaining a better understanding of cover crops and conservation-tillage was met in these studies and therefore the project can be considered successful as a whole. Results from the cover crop screening emphasized the strong and weak points of each cover crop for use in a conservation-tillage system. Rye produced the most biomass, or residue, but legumes produced more nitrogen. However, in both studies where different N rates were applied to both rye and legume cover crops, the effect of cover crop was not significant. In other words, cotton yields increased with increasing N rate regardless of which cover crop was used. It appears that the addition of 30 to 60 lb/a of sidedress N, depending on the fertility history of the field and nematode pressure, may optimize cotton yields. Although nematodes were not reported in this study, samples were taken and there are some indications that ‘Cherokee’ red clover and ‘Cahaba’ white vetch do not suppress nematodes as expected, and that rye may be the best cover crop to help keep nematode levels in check. The earliness of maturity of ‘AU Robin’ crimson clover and ‘AU Early Cover’ vetch make them good choices as legume cover crops for conservation-tillage system using cotton. The optimum planting window for cover crops seems to be from around the first of October to the end of Thanksgiving. Planting cover crops in December or later should be avoided if possible to maximize biomass and N production and avoid possible winterkill.

Future studies already implemented on-farm using cover crops in conservation-tillage include documented effects on nematode populations and the need for fertilization, especially N on small grain cover crops. Studies involving grazing of cover crops and then the effect on subsequent summer crop yields are also needed, as well as documentation of the long term effect of cover crops and conservation-tillage on soil organic matter levels and nutrient stratification.

ACKNOWLEDGMENTS

The authors wish to thank the farm cooperators, Mr. Tommy Dorminey, and Mr. Simmie King for their willingness to participate in this research and demonstration. These studies were funded in part by the Georgia Cotton Commission and through a special grant from the USDA-NRCS office of Bobby Brock in North Carolina to the Georgia Conservation Tillage Alliance. Support from the University of Georgia Agricultural Services laboratory, Wayne Jordan, Head, for soil and plant sample analyzes is also appreciated.

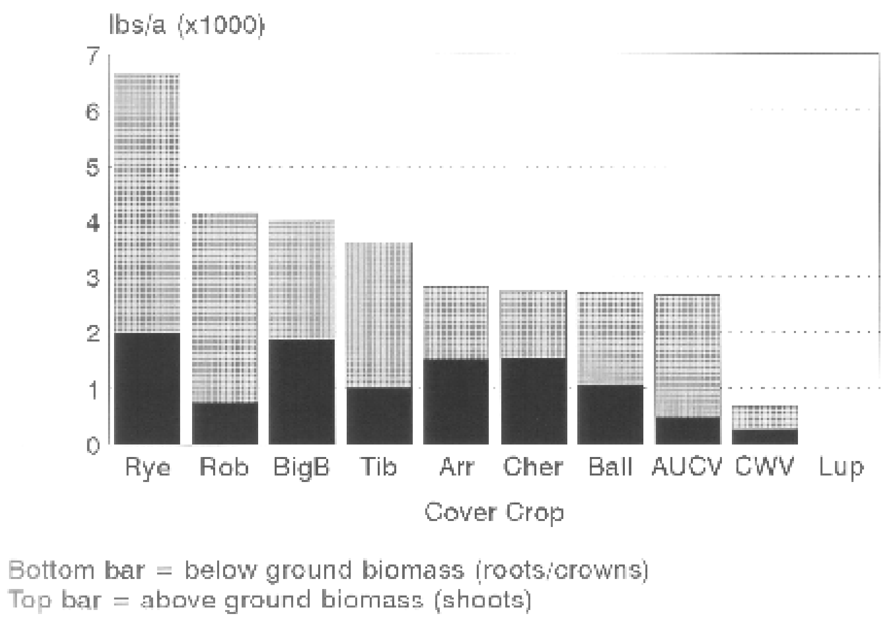


Fig 1. Above and below ground biomass production in cover crop screening study, Coffee County, GA, 1996.

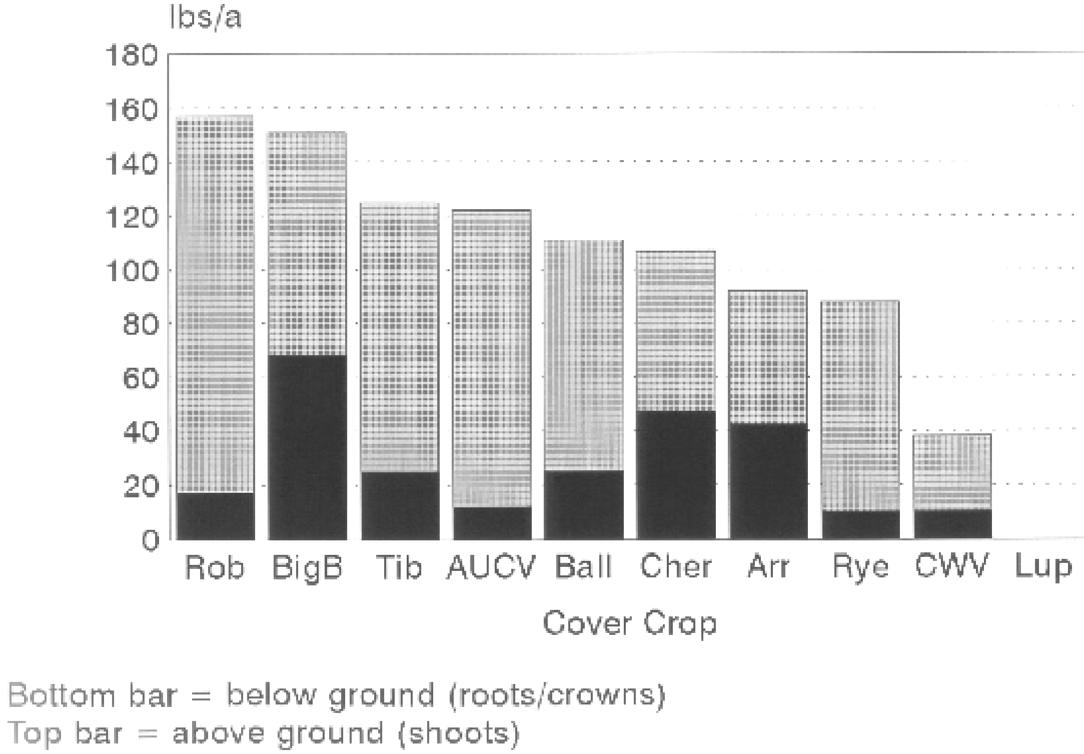


Fig. 2. Nitrogen production by above and below ground biomass in cover crops screen study, Coffee County, GA, 1996.

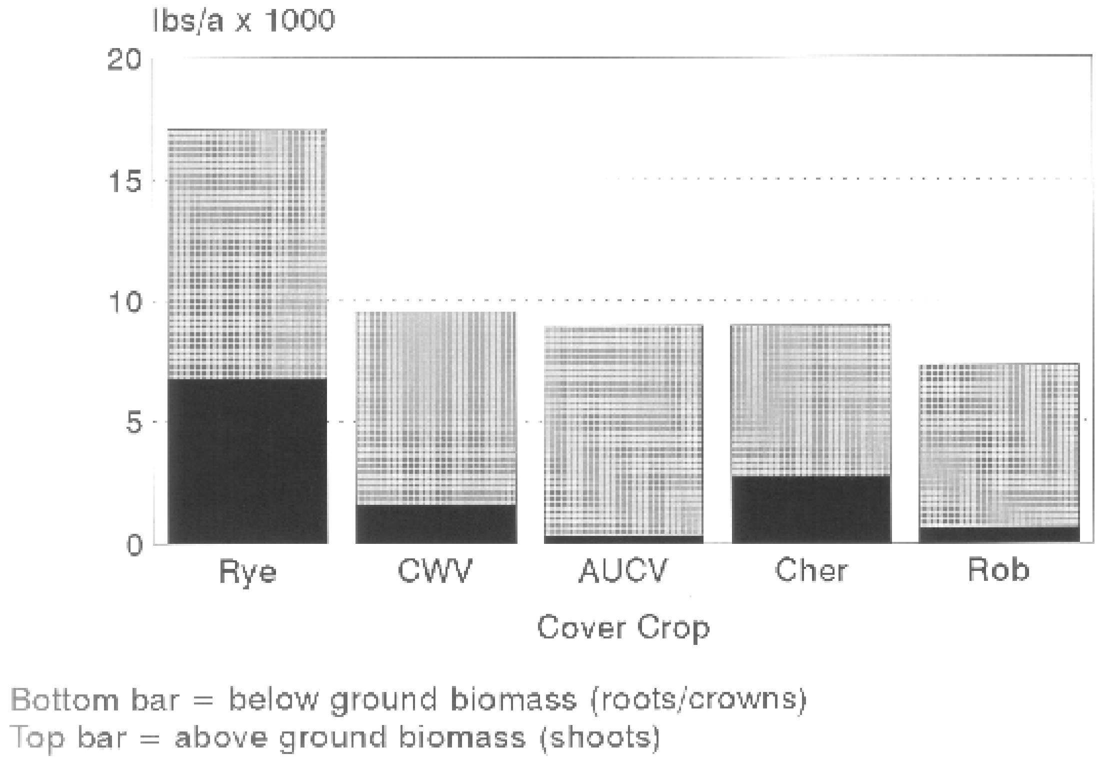


Fig. 3. Above and below ground biomass in timing of planting winter cover crop study, Coffee County, GA, 1997

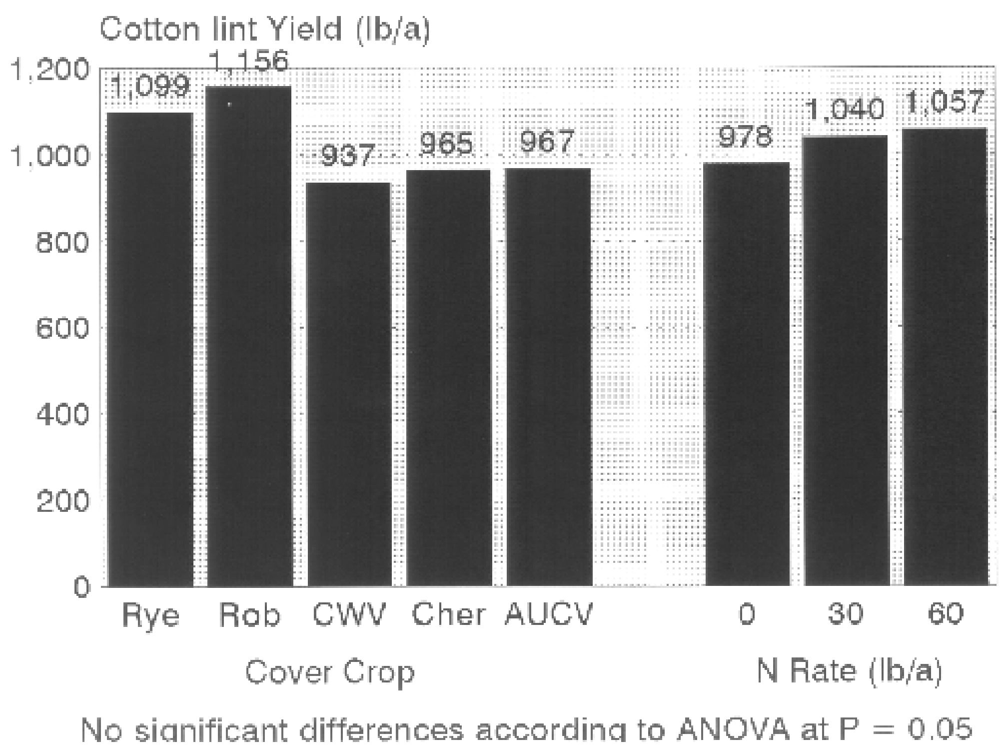


Fig. 4. Cotton yield response to cover crop and sidedress N rates, Coffee County, 1997.

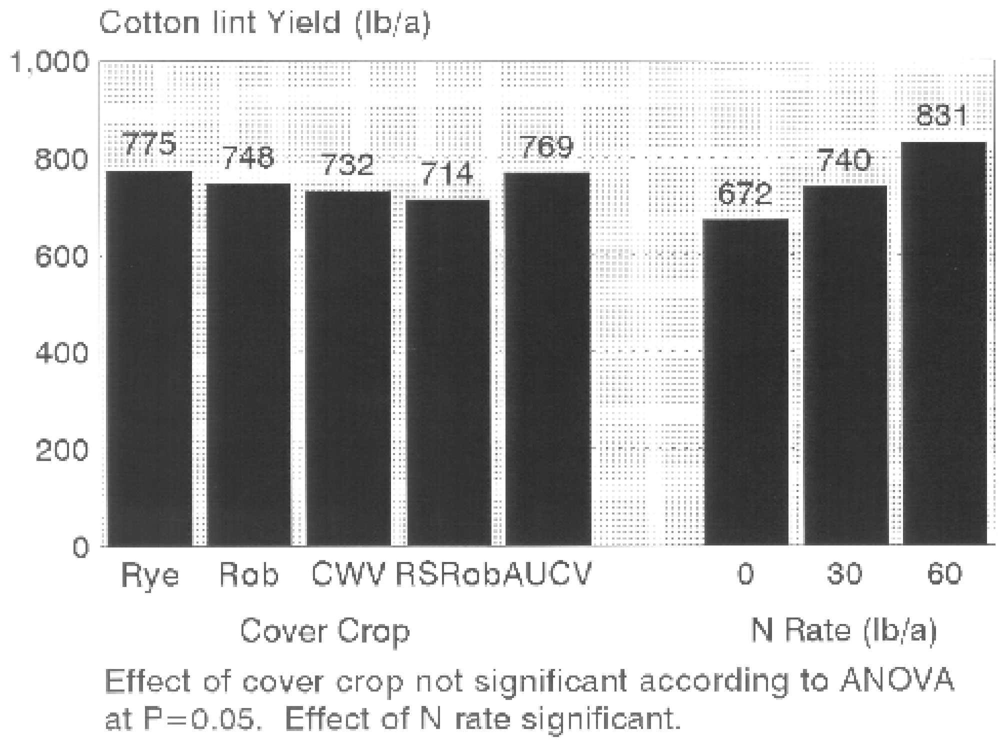


Fig. 5. Cotton yield response to cover crop and N sidedress rate, Coffee County, Effect of N rate is significant.

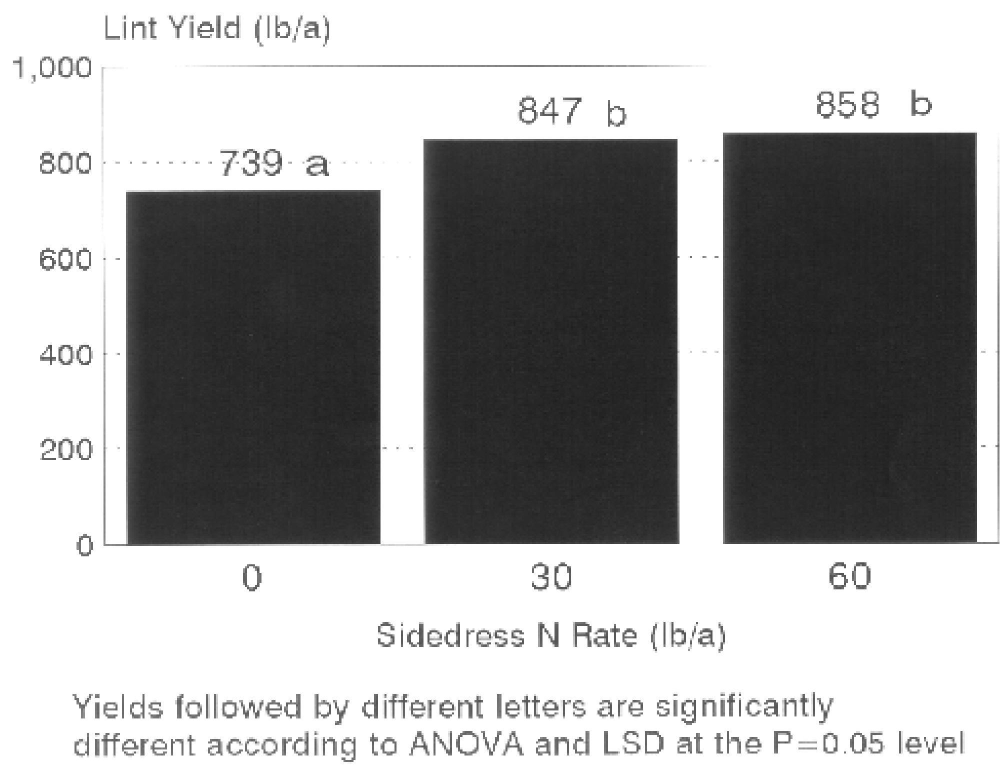


Fig. 6. Cotton yield response to sidedress N rates when following a crimson clover cover crop, Cook County, GA. 1998

NO-TILL IN THE NORTH CAROLINA BLACKLANDS: A CASE STUDY FOR FARMER-TO-FARMER EXCHANGE

Carl R. Crozier[1] and Sam Brake[2]

AUTHORS: [1]Assistant Professor, North Carolina State University Soil Science Department; [2]Manager, Open Grounds Farm, Inc. Corresponding author: C.R. Crozier, V.G. James Research & Extension Center, 207 Research Station Road, Plymouth, NC 27962, carl_crozier@ncsu.edu.
REFERENCE: J. E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

INTRODUCTION

Open Grounds Farm

Open Grounds Farm, Inc. encompasses approximately 35,000 acres in Carteret County North Carolina. This is in the Tidewater region of the state, generally described as low, flat, and wet. Average annual precipitation is 52.5 inches. Organic soils predominate, especially in shallow depressions or on broad flats with slow drainage (Goodwin, 1978; Lilly, 1981; Daniels et al., 1999).

Open Grounds Farm produces primarily corn and soybeans. In recent years, wheat and forage acreage has declined and cotton has been introduced. Although this farm is larger than other farms in the area, it is representative of much of northeastern North Carolina due to similar topography, soils, and land development. Regardless of overall farm size, the need for surface drainage results in fairly consistent field sizes, typically 320 feet wide (crowned to permit surface runoff to drainage ditches) by ½ to 1 mile long. At Open Grounds Farm, there are 69 blocks of land, each consisting of a series of such fields. Typical blocks are 1 square mile, bounded by main canals and roadways, and contain 16 narrow fields separated by smaller ditches.

Adopting No-Till Practices

No-till was first tried at Open Grounds in 1987 in an effort to reduce wind erosion and labor requirements. No-till production on highly erodible sloping lands had already become common throughout much of the rest of North Carolina during the 1980's. The first plantings included a small amount of corn, but were primarily double-cropped soybean into wheat stubble. The first no-till planters were purchased in 1991, and the farm established a goal of 50% of acreage to be planted no-till by 1996. Currently, half of the no-till planters operate with trash wheels, these are used to plant corn in fields with the heaviest residues. All of the cotton is planted using the trash wheels to enhance soil warming.

RESULTS AND DISCUSSION

Acreage and yield records

Acreage goals were met and exceeded for corn and soybeans (Figure 1). Relatively large increases in no-till acreage in 1995 were predominantly due to major land shaping efforts and to the direct conversion of pasture to no-till grain production. In 1999, it is expected that 99% of the corn, 82% of the soybean, and 100% of the cotton (5000 acres) will be planted no-till.

The main advantages with no-till perceived by the farm are increased yields (presumably due to moisture conservation) and a firmer soil surface for vehicle traffic. Farm records suggest that corn grain yield is generally a little higher with no-till (Figure 2). Initially, most no-till soybean was double-cropped and most conventional soybean was full-season, so it is difficult to assess the yield effect of tillage using these records.

Hurricanes and tropical storms frequently pass through this area in late summer and fall, and probably account for relatively low grain yields in 1996 and 1998 (Figure 2). Hurricanes still blow down no-till corn, but the firmer ground surface allows easier vehicle entry. Thus, corn can be harvested sooner after storms, which reduces grain deterioration and losses.

Soil preparation and labor issues

Switching to no-till production influences the timing of soil preparation work and the size of the total labor force required. Conventional tillage in this environment requires forming planting beds and cutting outlets (hoe drains) perpendicular to the crop rows to insure adequate drainage (Fig. 3a). With no-till, crops can be planted flat, which permits surface runoff without the need to excavate hoe drains (Fig. 3b). Nevertheless, the land must be carefully leveled to avoid ponding with no-till. Conventional tillage requires a much larger labor force during a few weeks at planting time (Table 1), especially considering that corn acreage has increased substantially (<12,500 to >15,000 acres) during the time the size of the planting crew has decreased (24 to 10 people). Labor savings are one of the main advantages of no-till on this farm.

Soil property changes

The firmer soil surface is another main advantage of no-till in this region. No-till can help break a cycle in which cultivated soils are more susceptible to rutting, and deep ruts need to be smoothed out with tillage. Rutting will still occur with no-till if the soil is sufficiently wet, and the farm expects to continue to practice some conventional tillage.

Nutrient stratification has been characterized in several no-till systems, and were recently evaluated across North Carolina (Crozier et al., 1999). Soil samples from non-replicated representative fields (all Wasda mucks, Histic Humaquepts) with different tillage history at Open Grounds Farm demonstrate that pH and nutrient stratification do occur, but this is not always clearly explained by soil management (Fig. 4). The surface soil pH in undeveloped land in this region is very acidic, and all cropping systems maintain a thin layer of slightly higher pH at the soil surface (Fig. 4a). The practice known as maximum tillage (disking, land-leveling, liming, field cultivator) appears to result in more similarity between soil pH of the 0-4” and 4-8” depth layers than occurs with minimum tillage (1 pass with disk or field cultivator) or with no-till. Nevertheless, similar degrees of disparity occur between the pH of surface 0-4” and the underlying 4-8” with minimum tillage and no-till, and with established no-till which has not received lime in 5 years and established no-till limed 1 year prior to sampling. Soil phosphorus stratification was consistent, with levels declining with soil depth in all fields (Fig. 4b). Soil copper stratification was consistent for all fields, except for uniformly high levels in fields recently used as pastureland (Fig. 4c).

The impacts of agricultural runoff on water quality are increasingly under review. Drainage from much of Open Grounds Farm empties into the Neuse River and the Albemarle-Pamlico Estuarine System, which are sensitive to eutrophication due to poor tidal flushing. Although the impacts of no-till on runoff water quality are not well understood in this region, we expect sediment runoff to be greatly reduced with no-till. Ditch maintenance records show less frequent cleanout is needed with no-till, suggesting a reduction in sediment loss from fields.

Farmer-to-Farmer exchange

Since beginning his career as an extension agent, the farm manager has continually communicated with other producers about improving farming practices. As an active member of the Blackland Farm Manager’s Association, he attends annual winter meetings and summer tours with a group of producers in the northeastern North Carolina organic soil region. As chair of the research committee of the North Carolina Soybean Producers Association, Inc., he is aware of innovations throughout the state. Open Grounds Farm has cooperated with university and corporate research and development programs involving variety testing, integrated pest management, pesticide efficacy trials, soil fertility, precision agriculture, and water quality.

Table 1. Size of the Labor Force Required to Plant Conventional till (Pre-1991) and No-till (Current) Corn Crops at Open Grounds Farm, Inc.

Prior to 1991		Present
# of people	Task	# of people
14	Disk, bed, hoe drains	0
8	Planting	8
2	Supply trucks	2
24	Total	10

Open Grounds Farm has been willing to describe its experiences and present farm records related to no-till at numerous producer and professional meetings. These include the Down East No-till Seminar (Greenville, NC, 1994), American Society of Agricultural Engineers Annual Meeting (Chicago, 1995), Southern Soybean Conference Annual Meetings (1996 and 1998), and the Monsanto Farm SMART conference (Raleigh, NC, 1998). In addition, Open Grounds Farm hosted the 1997 Blacklands Farm Manager’s Tour, where much of the information in this paper was presented. These shared experiences are particularly valuable in this area, which differs greatly in topography, climate, and soils from demonstration sites located in the rest of the state or in other states.

Manager’s Summary Advice

No-till production definitely has a place in these flat, wet soils. Careful land-leveling is needed to avoid ponding. For no-till to be successful, producers need to want to try it and be willing to work at it. Planting in heavy residue can be aggravating.

SUMMARY

Farm records are presented which describe no-till acreage and yields at Open Grounds Farm, Inc. in eastern North Carolina.

The soil types and management on this farm are representative of many grain and cotton farms in the Blackland region of northeastern North Carolina. This is not highly erodible land, but the farm expected no-till to reduce wind erosion as well as to reduce labor needs.

The farm exceeded its original goal of 50% of acreage in no-till. Increased yield and a firmer soil surface for vehicle traffic are perceived by the farm as the most significant advantages with no-till. Farm records suggest corn yields are generally slightly higher with no-till. Since initially most no-till soybean was double-cropped and most conventional till was full season, it is difficult to assess the yield affect of tillage on soybean yield. The size of the labor force required to plant the corn crop has decreased from 24 (for less than 12,500 acres prior to 1991) to 10 (for more than 15,000 acres now). Stratification of soil pH and nutrients has been noted, but this does not appear to be a cause for immediate concern.

No-till has the potential to maintain, and perhaps slightly enhance yields while reducing labor costs in this flat, wet region. It is a locally appropriate model for many farms in northeastern North Carolina, since it involves organic soils and the typical land development and drainage networks of this area.

REFERENCES

Crozier, C.R., G.C. Naderman, M.R. Tucker, and R.E. Sugg. 1999. Nutrient and pH stratification with conventional and no-till management. Communications in Soil Science and Plant Analysis 30:65-74.

Daniels, R.B., S.W. Buol, H.J. Kleiss, and C.A. Ditzler. 1999. Soil systems in North Carolina. Technical Bulletin 314, North Carolina State University Soil Science Department, Raleigh, NC.

Goodwin, R.A., Jr. 1978. Soil survey of Carteret County, North Carolina. United States Dept. of Agric., Soil Conservation Service.

Lilly, J.P. 1981. The blackland soils of North Carolina, their characteristics and management for agriculture. Technical Bulletin No. 270, North Carolina Agricultural Research Service, North Carolina State University, Raleigh.

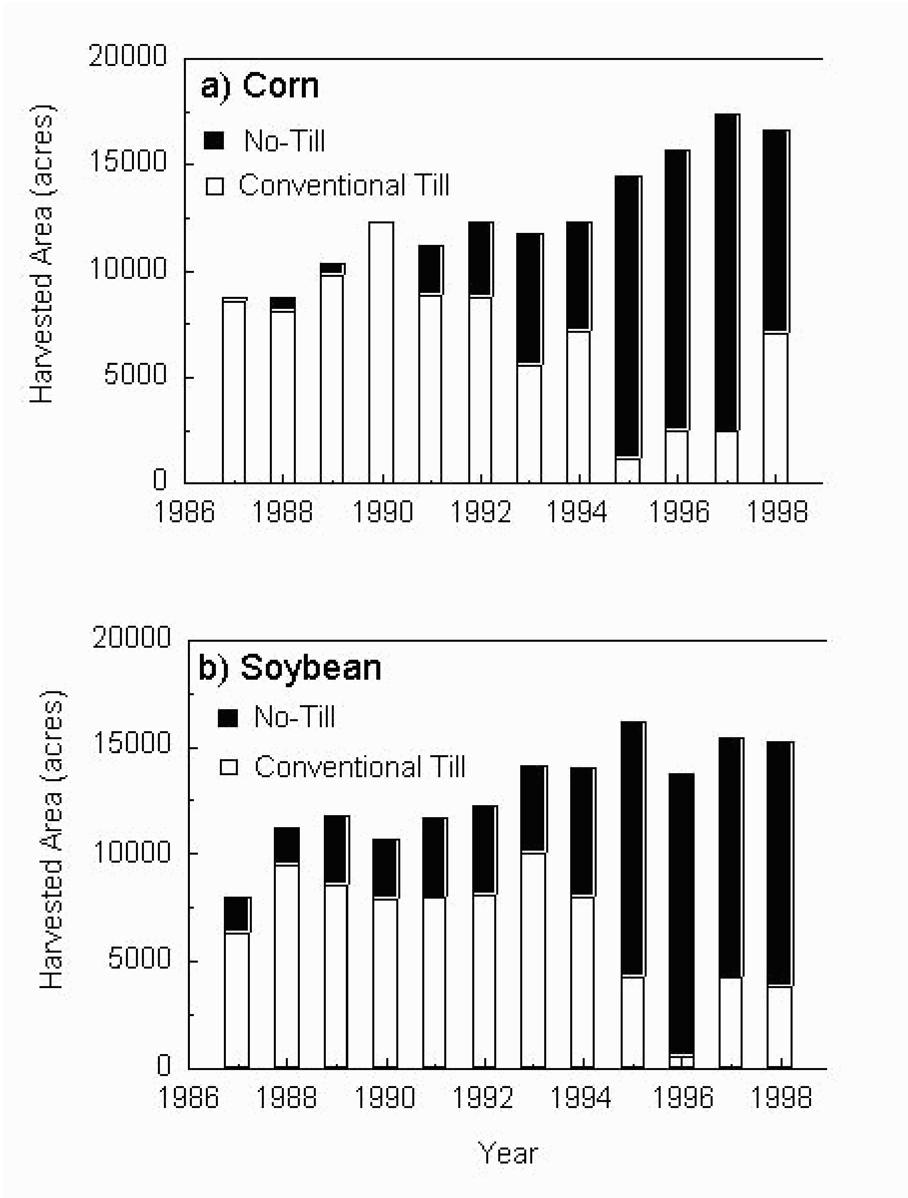


Figure 1. Harvested acreages of conventional and no-till planted corn (a) and soybean (b) at Open Grounds Farm, Inc.

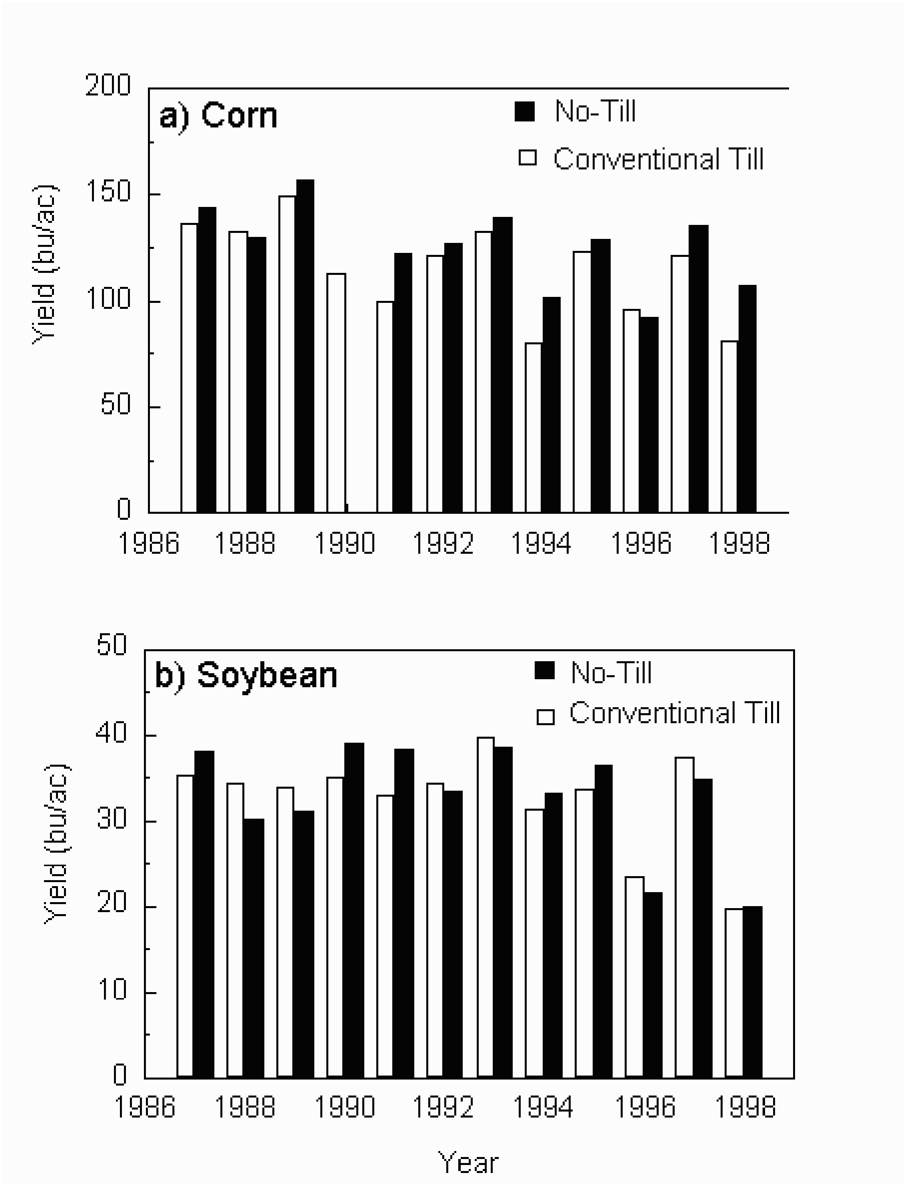


Figure 2. Average yields of conventional and no-till planted corn (a) and soybean (b) at Open Grounds Farm, Inc.

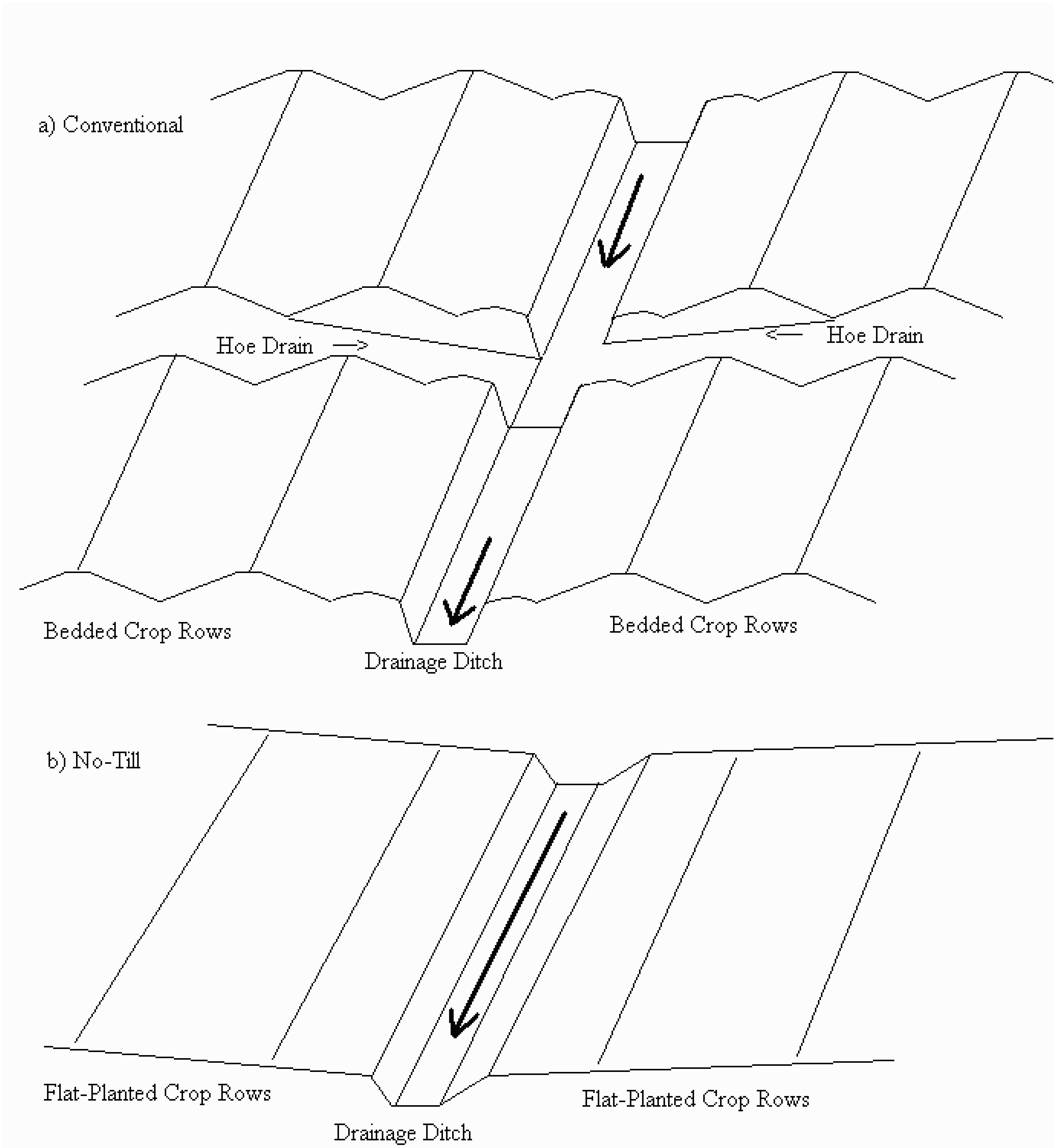


Figure 3. Typical land shaping for conventional (a) and no-till (b) planted corn and soybean at Open Grounds Farm, Inc.

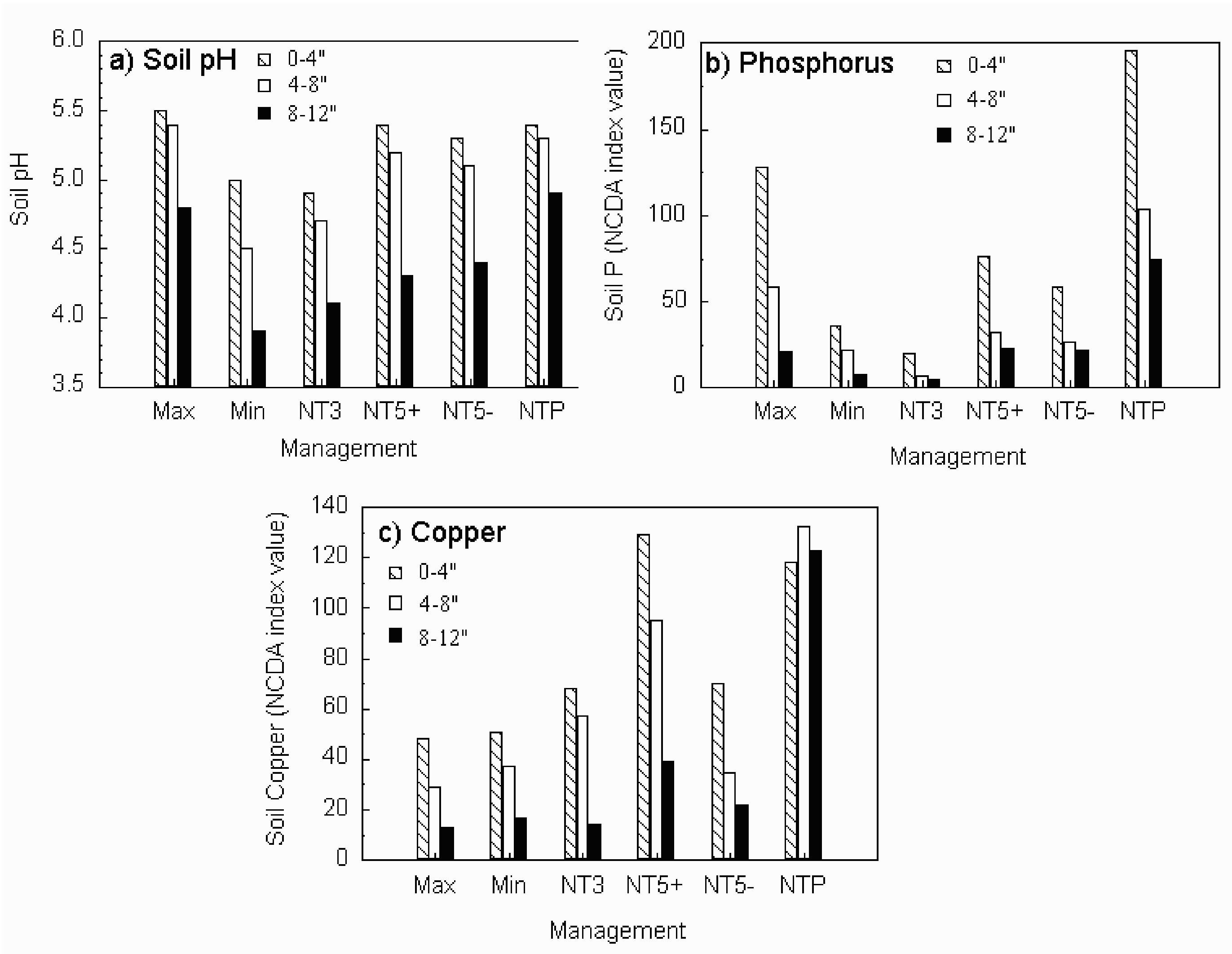


Figure 4. Soil test pH (a), phosphorus (b), and copper (c) levels measured from non-replicated fields with Wasda muck soil type. The management treatments sampled were: Max-Till (disking, land-leveling, liming, field cultivator); Min-Till (1 pass with disk or field cultivator), NT 3yr (3 years of continuous no-till), NT 5+ (5 years of continuous no-till with lime 1 year ago), NT 5 – (5 years of continuous no-till without any lime), and NT past (no-till following use of a herbicide to kill pasture).

CONSERVATION TILLAGE CONFERENCE
TILLAGE AND NITROGEN INFLUENCE ON COTTON

P. J. Wiatrak[1], D. L. Wright[1], F. M. Rhoads[1], S. Reed[2], and J. Pudelko[3]

AUTHORS:[1]North Florida Research and Education Center, Quincy, FL 32351-9529; [2]Florida A and M University, Tallahassee, FL; [3]Agriculture University Institute of Soil Culture and Plant Production, Mazowiecka 45/46, 60-623 Poznan, Poland. [1]Corresponding author. *REFERENCE:* J. E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*. Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. The experiment was conducted during 1996 - 1998 on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) at the North Florida Research and Education Center, Quincy, FL. The objectives of this study were to determine optimum N rates for cotton, the impact of fallow, small grain and legume as winter covers on N requirements of cotton, and to compare N requirements in strip tilled cotton with conventional plantings. The lint cotton yields were significantly different between years and were influenced by previous crop, N rates, and the interaction of tillage and previous crops. Significantly lower yields were obtained in 1998 due to hard-locks. Higher yields of cotton were obtained after crimson clover than wheat or fallow. There was a significant positive response to N between 0 and 60 lb N/acre and between 60 and 120 lb N/acre but no response between 120 and 180 lb N/acre. Cotton bolls were heavier after strip-till than conventional till and also heavier after fallow than wheat. There was no statistical difference for the boll weight between crimson clover and fallow and between crimson clover and wheat. Positive response of boll weight to N occurred between 0 and 60 lb N/acre but N rates higher than 60 lb/acre reduced the weight of bolls. Plant height was increased with higher N rates. Rates of N produced a range in plant height from about 2 feet with zero N to over 3 feet with 180 lb of N/acrecre. Plants were significantly higher in strip-till than conventional planting and higher after crimson clover than wheat and fallow. The interaction of previous crops and N rates shows that plants were higher after crimson clover than fallow with no N application but at the higher nitrogen rates the differences between previous crops were not significant. Height response to N application was greater after fallow than crimson clover or wheat.

INTRODUCTION

Research conducted during 1987-92 (Hutchinson et al., 1993) showed that the yields of cotton grown in minimum tillage were similar to yields obtained from conventional tillage. In many cases the yield of cotton was higher on areas, where minimum tillage was applied (no-till and ridge-till) together with previous crops (Hutchinson et al., 1993), but the cotton yield was not always higher (Stevens et al., 1992). However, cotton grown in the minimum tillage after small grains required higher N rates than cotton grown with no previous crop (Brown et al., 1985).

Experiments conducted through many years have shown that legume crops may increase the organic matter in the soil (Frye and Blevins, 1989), improve soil texture (Beale et al., 1955) and productivity (Frye et al., 1985). Using "mulch" from legume crops improves the soil capacity to hold water (Griffith et al., 1886) and infiltration (Touchton et al., 1984), and at the same time decrease the erosion and water flow (Frye et al., 1985). One of the biggest agronomic benefits from growing legume crops is their ability to distribute biologically fixed N, which may reduce nitrogen fertilization of the next crop (Brown et al., 1985). Hutchinson et al., (1994) showed that cotton grown after Vicia (Vicia Villosa. R.) didn't require application of N to get the optimum yields; however, this same plant grown after wheat required application of 40 kg/ha more N to get optimum yield compared to cotton grown after fallow.

The purpose of this work was to examine the influence of tillage, previous crop, and N rates on cotton.

MATERIALS AND METHODS

The experiment was conducted during 1996 - 1998 on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) at the North Florida Research and Education Center, Quincy, FL. Following are the applied tillage, winter cover, and fertility treatments:

I. Tillage (main plots):
  1. Strip tillage
  2. Conventional.

II. Winter cover crop (sub plots):
  1. Fallow
  2. Legume
  3. Wheat

III. Nitrogen fertilizer rates on cotton (lb/acre) (sub sub plots):
  1. 0 lb/acre
  2. 60 lb/acre
  3. 120 lb/acre

4. 180 lb/acre

Winter crops were planted in the fall of 1996 and 1997 only. Pioneer 2684 wheat was planted at 1.5 Bu/acre (90 lb/acre) only on the plots with this winter crop and crimson clover was planted at 27 lb/acre with a Great Plains No-till Drill. The study was irrigated as needed. On April the entire study was sprayed with Roundup @ 1 qt/acre in order to prepare the field to plant cotton. The conventional sections of the experiment were mowed, disc-harrowed (2x), chisel-plowed (1x), and s-tine harrowed (1x) to prepare a good seedbed for cotton seeds in May. In mid May NuCotn 33B (in 1996 and 1997) and DP 458 BR cotton (in 1998) were planted in conservation till and conventional system with a 2-row Brown Ro-till and KMC planters at 3-4 seeds/ft of 36 inch wide rows together with the application of Thimet at 3½ lb/acre. The same day cotton was side-dressed with 350 lb/acre of 3-9-18 fertilizer. Cotton was side-dressed with nitrogen (34-0-0) treatments of 60, 120, and 180 lb N/acre (the treatment with 180 lb N/acre had 120 lb N/acre applied at 40 days and 60 lb N/acre at 70 days after planting). Cotton was picked with a 782 International Cotton Spindle Picker. The lint cotton yield was calculated as 38% of seed cotton yield. Data were analyzed using SAS (1989) by analysis of a variance, and means were separated using Fisher's Least Significant Difference Test at the 5% probability level.

RESULTS

Lint cotton yields were significantly different between years and were influenced by previous crop, N rates, and the interaction of tillage and previous crops. Significantly lower yields were obtained in 1998 due to hard-locks of cotton in all plots which reduced mechanically harvested yields (Figure 1). Main effect of tillage was not significant for the lint yields (Table 1). Higher yields of cotton were obtained after crimson clover (756 lb/acre) than wheat or fallow (705 and 694, respectively). The interaction of tillage and previous crop was due to getting higher lint yields in strip-till than conventional till after fallow (712 and 677 lb/acre, respectively) while yields were higher in conventional till after crimson clover (minimum difference) and wheat (739 and 669 lb/acre, respectively) compared to strip-till. There was a significant (*P* # 0.05) positive response to N between 0 and 60 lb N/acre and between 60 and 120 lb N/acre but no response between 120 and 180 lb N/acre (Figure 2).

The weight of cotton bolls was influenced by tillage, previous crop, N rates, the interaction of tillage and previous crop, and the interaction of previous crop and N rates (Table 2 and 3). Cotton bolls were heavier after strip-till than conventional till (4.40 and 4.29 gms, respectively). Comparing previous crops, heavier bolls were obtained after fallow than wheat (4.42 and 4.21 gms, respectively). There was not statistical difference for the boll weight between crimson clover and fallow and between crimson clover and wheat. Positive response to N occurred between 0 and 60 lb N/acre and higher than 60 lb N/acre reduced the weight of bolls . The interaction of tillage and previous crop indicated heavier bolls in strip-till than conventional after fallow and crimson clover, and heavier bolls in conventional than strip-till after wheat. The interaction of previous crop and N rates showed that after crimson clover and wheat, application of higher than 60 lb N/acre reduced the weight of bolls significantly but after fallow higher rates did not change the boll weight.

Plant height was influenced by tillage (Figure 3), previous crop, N rates, and interaction of previous crop and N rates (Table 4). Plants were significantly taller in strip-till than conventional planting (2.87 and 2.68 ft.) and taller after crimson clover than wheat and fallow (2.93, 2.73, and 2.66 ft., respectively). Plant height was increased with higher N rates. Rates of N produced a range in plant height from about 2 feet with zero N to over 3 feet with 180 lb of N/acre. The interaction of previous crops and N rates shows that plants were taller after crimson clover than fallow with no N application but at the higher nitrogen rates the differences between previous crops were not significant. Higher response to the N application occurred after fallow than crimson clover or wheat.

CONCLUSIONS

1. r yields of cotton were obtained after crimson clover than wheat or fallow.

C Nitrogen application up to 120 lb/acre significantly increased lint yield of cotton.

C Cotton bolls were heavier in strip-till than conventional till, heavier after fallow than wheat with positive response to N rate of up to 60 lb/acre.

C Plant height was greater in strip-till than conventional planting and greater after crimson clover than wheat and fallow, and increased with increasing N rates on cotton.

REFERENCES

Beale, V. W.., G. B. Nutt, and T. C. Peele. 1955. The effects of mulch tillage on runoff, erosion, soil properties, and crop yields. Soil Sci. Soc. Am. Proc., 19:244-247.

Brown, S. M.., T. Whitwell, J. T. Touchton, and C. H. Burmester. 1985. Conservation tillage systems production for cotton production. Soil

Hutchinson, R. L., G. A. Breitenbeck, R. A. Brown, and W. J. Thomas. 1994. Effects of tillage systems and cover crops on nitrogen fertilizer requirements of cotton. pp. 70-76. In Proc. of the 1994 South. Cons. Till. Conf.

for Sust. Agric. Columbia, SC, June 7-9.

Hutchinson, R. L., R. A. Brown, B. R. Leonard, and C. W. Kennedy. 1993. Effects of tillage systems and winter cover crops on yield and maturity of cotton on a loess soil in northeast Louisiana. Pp. 85-91. Proc. 1993 South. Cons. Till. Conf. Louisiana Agric. Exp. Sta. Manuscript no. 93-86-7122.

SAS Institute Inc. 1989. SAS/STAT user's guide version 6, 4th ed., vol. 1 and 2. SAS Institute Inc., Cary, NC. 1789 pp.

Stevens, W. E., J. R. Johnson, J. J. Varco and J. Parkman. 1992. Tillage and winter cover management effects on fruiting and yield of cotton. J. Prod. Agric. 5: 570-575.

Touchton, J. T., D. H. Richerl, R. H. Walker, and C. E. Snipes. 1984. Winter legumes as a nitrogen source for no-tillage cotton. Soil Tillage Res., 4:391-401.

Table 1. Influence of Tillage and Previous Crop on Lint Cotton Yields at NFREC, Quincy, FL (3 Yr. Avg.)

Tillage	Previous crop			Avg.
	Fallow	Crimson Clover	Wheat	
	---------- lb/acre ----------			
Strip-till	712	748	669	709
Conv.	677	764	739	715
Avg.	694	756	705	712

$LSD_{(0.05)}$ for tillage NS
$LSD_{(0.05)}$ for previous crops 40.5
$LSD_{(0.05)}$ for tillage x previous crops 55.2

Table 2. Influence of Tillage and Previous Crop on Boll Weight of Cotton at NFREC, Quincy, FL (3 Yr. Avg.)

Tillage	Previous crop			Avg.
	Fallow	Crimson Clover	Wheat	
	---------- gms ----------			
Strip-till	4.50	4.46	4.09	4.40
Conv.	4.34	4.03	4.32	4.29
Avg.	4.42	4.30	4.21	4.35

$LSD_{(0.05)}$ for tillage0.13
$LSD_{(0.05)}$ for previous crops 0.17
$LSD_{(0.05)}$ for tillage x previous crops 0.22

Table 3. Influence of Previous Crop and N Rates on Boll Weight of Cotton at NFREC, Quincy, FL (3 Yr. Avg.)

N rates	Previous crop			Avg.
	Fallow	Crimson Clover	Wheat	
	---------- gms ----------			
0	4.31	4.31	3.89	4.22
60	4.48	4.61	4.55	4.52
120	4.42	4.30	4.31	4.37
180	4.45	3.96	4.08	4.27
Avg.	4.42	4.30	4.21	4.35

$LSD_{(0.05)}$ for previous crops0.17
$LSD_{(0.05)}$ for N rates0.18
$LSD_{(0.05)}$ for previous crops x N rate 0.32

Table 4. influence of Previous Crop and N Rates of Plant Height of Cotton at NFREC, Quincy, FL (3 Yr. Avg.)

N rates	Previous Crop			Avg.
	Fallow	Crimson Clover	Whear	
	---------------ft---------------			
0	1.88	2.53	2.06	2.14
60	2.65	2.93	2.69	2.75
120	3.02	3.13	2.89	3.01
180	3.09	3.12	3.29	3.16
Avg.	2.66	2.93	2.73	2.76+

$LSD_{(0.05)}$for previous crops 0.14
$LSD_{(0.05)}$for N rates 0.1
$LSD_{(0.05)}$ for previous crops x N rates 0.28

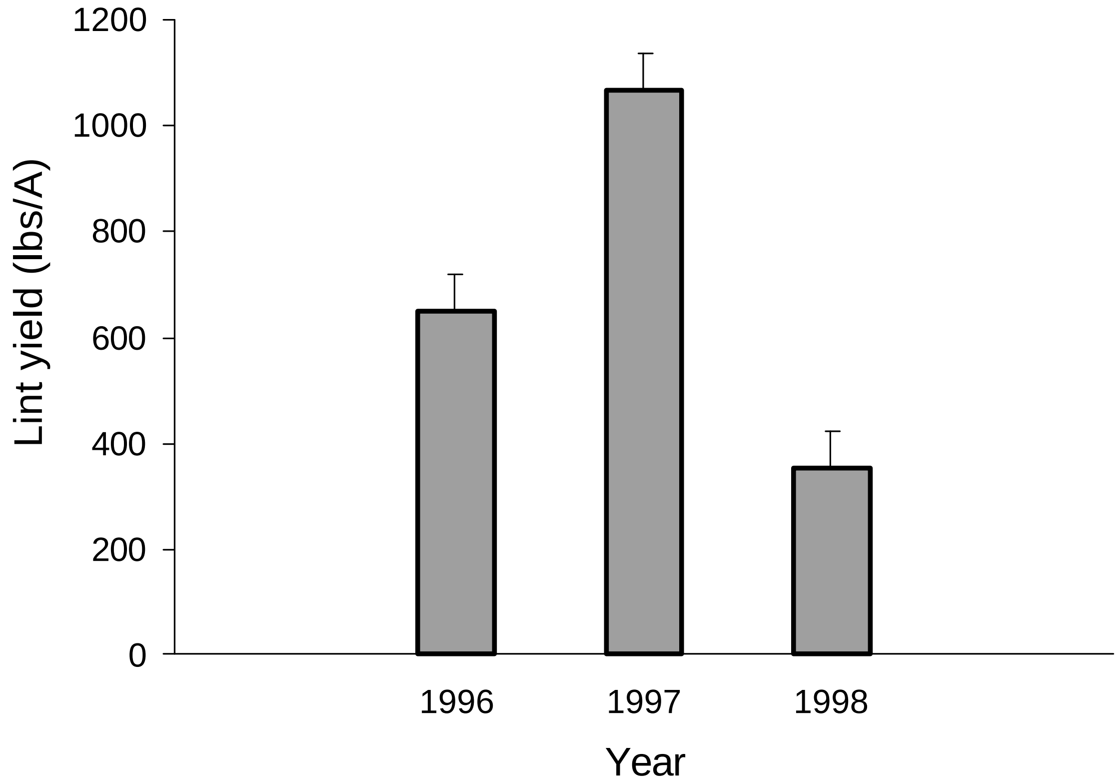


Fig. 1. Average lint cotton yields (lb/acre) over three years at NFREC, Quincy, FL.

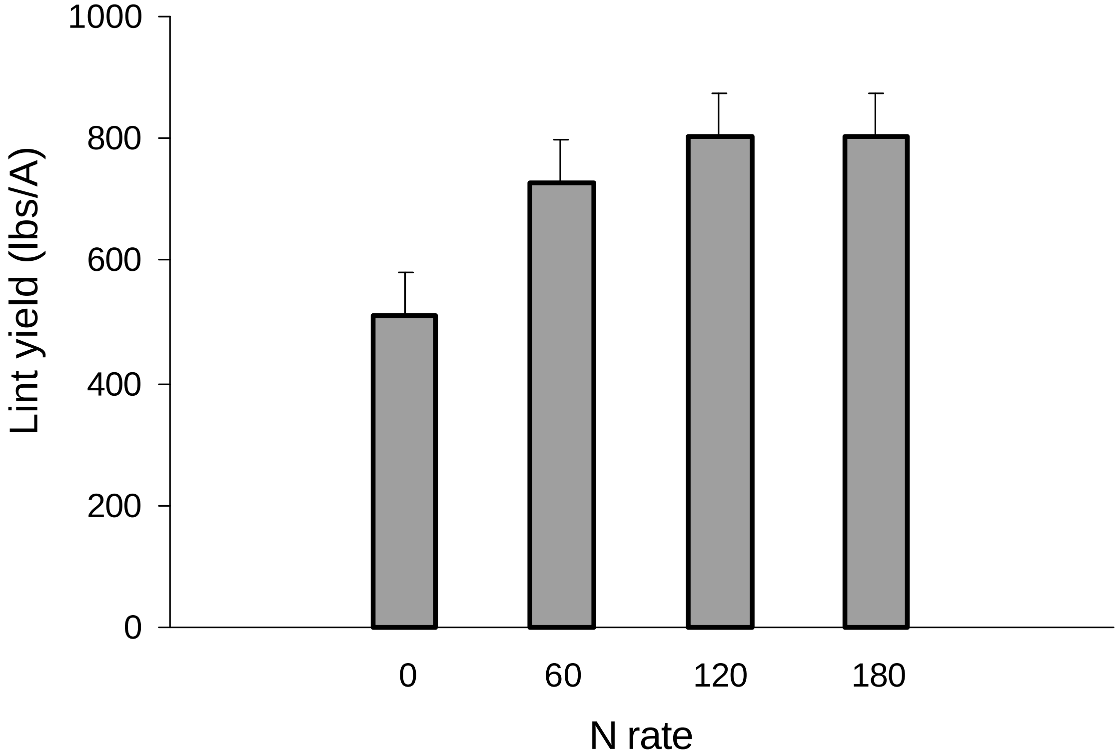


Fig. 2. Influence of N rates on lint cotton yields (3 yr. avg.)

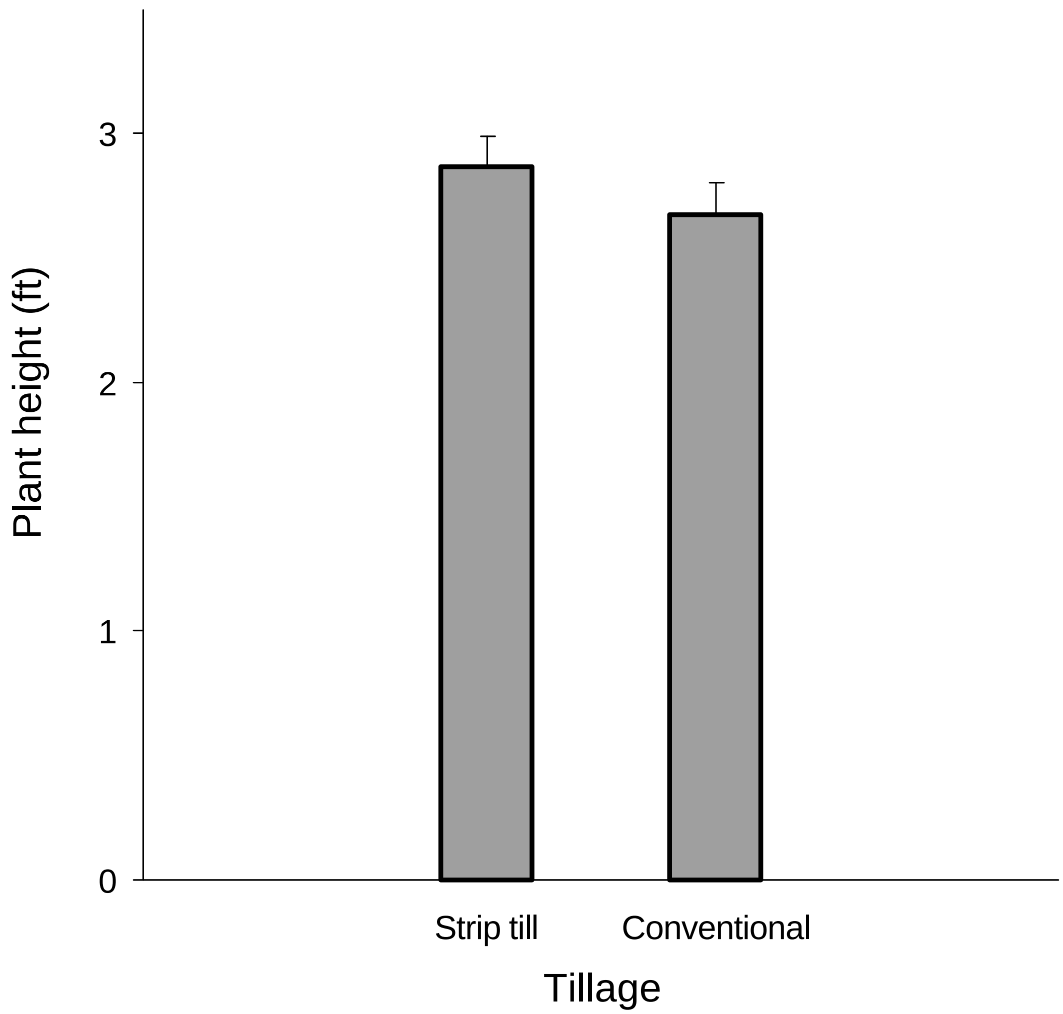


Fig 3. Influence of tillage on plant height of cotton at NFREC, Quincy, FL (3 yr. avg.)

WEED MANAGEMENT PROGRAMS IN NO-TILL COTTON, PEANUT, AND SOYBEAN

M.W. Edenfield[1], R.N. Gallaher[2], B.J. Brecke[3], and J.A. Tredaway[4]

AUTHORS: [1]Graduate Research Assistant, [2]Professor, and [4]Assistant Professor Agronomy Department, University of Florida, Gainesville. [3]Professor, University of Florida West Florida Research and Education Center, Jay, FL. *Corresponding Author: M.W. Edenfield, P.O. Box 110500. University of Florida, Gainesville, FL 32611; E-mail: mwe@ufl.edu.

REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*. Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. Strip-till (in-row subsoil no-till) crop management continues to be a viable alternative to conventional tillage. Field experiments were conducted in 1998 to evaluate herbicide programs for weed control and yield improvement in Roundup Ready cotton (*Gossypium hirsutum*) ('DP 5415 RR'), peanut (*Arachis hypogaea*) ('Georgia Green'), and Roundup Ready soybean (*Glycine max*) ('Hartz 7550 RR'). Treatments were randomized in a complete block design and crops were direct seeded into rye (*Secale cereale*) residue. One early postemergence (EPOT) followed by a post-directed spray (PDS) of Roundup Ultra provided the best overall weed control and cotton lint yield (1168 lbs/acre). Cotoran (fluometuron) PRE followed by Bladex (cyanazine) plus Bueno 6 (MSMA) PDS provided equal control at the late rating of sicklepod (*Senna obtusifolia*) with two applications of Roundup Ultra but this treatment resulted in less control of Texas panicum (*Panicum texanum*) and pitted morningglory (*Ipomoea lacunosa*). Starfire (paraquat) plus Basagran (bentazon) plus surfactant at-cracking (AC) followed by Cadre (imazapic) plus surfactant (POST) resulted in excellent weed control and peanut pod yield (4067 lbs/acre). Cadre POST resulted in similar weed control and pod yield (4139 lbs/acre) as the AC Starfire treatment followed by Cadre POST with the exception of Texas panicum control (<90%). Two applications of Roundup Ultra provided best total weed control and the highest soybean yield (46.8 bu seed/acre). A single application of Roundup Ultra EPOT resulted in similar control of volunteer peanut, but gave less control of pitted morningglory, sicklepod and Texas panicum resulting in lower yield (34.7 bu seed/acre).

INTRODUCTION

Reduced tillage crop production is becoming more widely accepted by growers in the southeastern U.S. There are several advantages with no-tillage production systems including reduced soil erosion, lower fuel requirements, greater flexibility in planting, reduced labor requirements, adaptability to most crops, reduced equipment requirements, and improved water retention (Phillips, 1984; Gallaher and Hawf, 1997). No-till planting of agronomic crops into rye (*Secale cereale* L.) residue provides all of the above benefits, especially water conservation (Gallaher, 1977).

Weed control is often considered one of the major hindrances to the successful adoption of conservation tillage systems. A shift in the spectrum of weed species may occur when tillage practices are altered because tillage favors annual weed species while no-tillage favors a reduction in such weed species (Kells and Meggitt, 1985; Phillips, 1984). Conversely, minimum tillage practices tend to increase the numbers of perennial species, especially grasses, which are often much more difficult to control under no-till conditions (Witt, 1984). As tillage is reduced, weed germination may extend over a longer period of time. As a result, the acceptance of conservation tillage practices has been dependent on the development and availability of herbicides for postemergence (POST) weed control. As tillage is reduced, a greater dependence on herbicides, especially POST applications, will follow.

Cotton (*Gossypium hirsutum* L.) and peanut (*Glycine max* L. Merr) acreage has significantly increased in north central Florida over the past 20 years, which has helped offset the loss in acreage of other field crops such as soybean (*Glycine max* L. Merr) (Gallaher and Brecke, 1998). This overall increase has been accompanied by a substantial increase in utilization of reduced tillage production systems. Each of these crops remains economically important and the newly developed Roundup Ready cotton and soybean varieties should improve management, yields, and profits for Florida growers. For this reason it is important to determine weed management strategies under Florida conditions. Therefore, the objectives of this research were to determine treatment requirements for optimum weed control in strip-till Roundup Ready cotton, strip-till peanut, and strip-till Roundup Ready soybean.

MATERIALS AND METHODS

Experiments were conducted in 1998 at the Green Acres Agronomy Field Research Laboratory, 12 miles west of Gainesville, Florida. Soil type was Arredondo fine sand (Sandy Sileceous Thermic Paleudult), and consists of 95 to

97% sand and 3 to 5% silt plus clay (Soil Survey Staff, 1994). Treatments were randomized in a complete block design with six replications. Each 4-row plot was 20 feet long and had rows spaced 30 inches apart. When rainfall was inadequate experiments were irrigated to ensure a minimum of 1 1/4 acre inches of water per week throughout the growing season. All summer crops were preceded by a winter crop of 'Wrens Abruzzi' rye for grain and were direct seeded into the rye residue with a Brown-Harden strip-till planter. Cotton ('DP 5415 RR'), peanut ('Georgia Green') and soybean ('Hartz 7550 RR') were planted directly into the rye residue at a rate of 6, 6, and 10 seed per linear foot of row, respectively.

Glyphosate Resistant Cotton

Preemergence (PRE) herbicides common to all treatments and which also served as the control treatment consisted of 2 lb a.i./acre Roundup Ultra (glyphosate) plus 0.75 lb a.i../acre Prowl (pendimethalin). The four herbicide treatments evaluated included 1) a control; 2) a single over-the-top early postemergence (EPOT) application of Roundup Ultra at 0.75 lb a.i./acre applied to 4 leaf cotton; 3) a sequential application of Roundup at 0.75 lb a.i./acre EPOT followed by a post-directed spray (PDS) of Roundup Ultra at 0.75 lb a.i./acre; and 4) Cotoran (fluometuron) PRE at 1.5 lb a.i./acre followed by a PDS spray of Bladex (cyanazine) at 0.75 lb a.i./acre plus Bueno 6 at 2.0 lb a.i./acre.

Fertilizer (13 (N)-5(P_2O_5)-29(K_2O)-1(Mg)-2.5(S)/acre) was applied prior to planting. An additional application of 60 pounds N/acre as ammonium nitrate was sidedressed mid-season. Six applications, made 7 to 14 days apart, of labeled rates of Lannate (methomyl) and Baythroid (cyfluthrin) were used for insect control beginning 10 July and ending 24 August.

Peanut

A broadcast application of 200 pounds muriate of potash (KCl)/acre and 200 pounds sulphate of potash magnesium (K_2SO_4:$MgSO_4$)/acre was made at planting. Preemergence herbicides common to all treatments and which also served as the control treatment consisted of Roundup Ultra at 0.75 lb a.i./acre plus Prowl at 1.00 lb a.i./acre. The four herbicide treatments included a 1) control; 2) at-cracking (AC) application of Starfire (paraquat) at 0.125 lb a.i./acre plus Basagran (bentazon) at 0.5 lb a.i./acre; 3) the AC application in treatment 2 followed by a POST application of Cadre (imazapic) at 0.063 lb a.i./acre; and 4) Cadre at 0.063 lb a.i./acre POST. Induce (non-ionic surfactant) at 0.25% v/v was included in all herbicide mixtures following PRE.

Glyphosate Resistant Soybean

A broadcast application of 200 pounds muriate of potash (KCl)/acre and 200 pounds sulphate of potash magnesium (K_2SO_4:$MgSO_4$)/acre was made PRE. Preemergence herbicides common to all treatments and which also served as the control treatment consisted of Roundup Ultra at 2 lb a.i./acre plus Prowl at 0.75 lb a.i./acre. The four herbicide treatments evaluated included a 1) control; 2) single application of Roundup Ultra at 0.75 lb a.i./acre EPOT; 3) sequential application of Roundup Ultra at 0.75 lb a.i./acre EPOT and POST; and 4) Sencor (metribuzin) PRE at 0.38 lb a.i./acre followed by Classic (chlorimuron) at 0.008 lb a.i./acre plus Induce at 0.25 % v/v POST.

Weed control evaluations in each experiment were made at two dates in 1998, 18 July and 22 August. Evaluations were based on visual observations of treated plots compared to the control treatment, with 100% representing complete weed control and 0% being no control. At the end of the season crop yield was determined from the two center rows of the four row plots.

Data was recorded and transformed as appropriate using Quattro Pro for windows (1987) spreadsheet software and analyzed using MSTAT 4.0 (Nissen, 1985). When treatments were significant at the 0.05 level of probability, means were separated using the LSD test.

RESULTS AND DISCUSSION

Glyphosate Resistant Cotton

The sequential treatment of Roundup Ultra EPOT followed by Roundup Ultra POST provided the best overall weed control for all species evaluated. Cotoran PRE followed by a PDS spray of Bladex plus Bueno 6 did ultimately provide season-long control of sicklepod (*Senna obtusifolia*) equal to that obtained with Roundup Ultra. Nonetheless, a sequential application of Roundup Ultra maintained the best control of Texas panicum (*Panicum texanum*) and pitted morningglory (*Ipomoea lacunosa*) of the herbicide treatments evaluated (Table 1). Furthermore, a single application of Roundup Ultra was not better than Cotoran PRE followed by a PDS of Bladex plus Bueno 6 control of pitted morningglory on 22 August.

Lint yield was positively correlated with the level of weed control and was greatest with the sequential application of Roundup Ultra (Table 1). Yield was 65% greater for the sequential application of Roundup Ultra compared with only one application. If one assumes a lint cotton price of $0.60/pound, then the extra Roundup Ultra application would add $261/acre to gross returns.

Peanut

An AC treatment of Starfire plus Basagran followed by Cadre POST provided complete control of weeds that were rated on both dates (Table 2). However, a small amount of peanut stunting occurred with this treatment compared to other herbicide treatments. Both the AC treatment alone and Cadre alone provided less Texas panicum control than the sequential application.

Peanut yield was similar for Starfire plus Basagran AC followed by Cadre POST and Cadre POST without the AC treatment even though weed control was less for Cadre alone. Both treatments yielded better than the AC treatment alone. Therefore, based on these data the appropriate choice under conditions of this study would be the weed control program prescribed employing both the AC and POST treatment. If one assumed that peanut in the shell sold for $0.50/pound, then the herbicide treatments following PRE provided an increased gross return of $1660/acre over the control. However, additional testing will be necessary to provide accurate extension recommendations for specific cropping systems and varieties in order to maximize strip-till peanut yield and profit.

Glyphosate Resistant Soybean

Weed ratings (Table 3) show that two sequential POST applications of Roundup Ultra provided the best overall weed control. This was especially true for sicklepod and Texas panicum compared to a single application of Roundup Ultra. Sencor PRE followed by Classic ultimately provided sicklepod and pitted morningglory control equal to that of a sequential application of Roundup Ultra, however, this treatment did not control Texas panicum or volunteer peanut.

As was the case for best overall weed control, seed yield was also greatest for a sequential application of Roundup Ultra (Table 3). Yields for the sequential Roundup Ultra application was 29 and 35 % greater than those of a single application of Roundup Ultra and Sencor PRE followed by Classic POST, respectively. If one assumed that soybean sold for $5/bushel, then the sequential application of Roundup Ultra would provide an increase in gross returns of $60/acre compared to a single application of Roundup Ultra.

ACKNOWLEDGMENTS

Authors extend appreciation to the technical assistance of Howard Palmer, Walter Davis and Jim Chichester.

LITERATURE CITED

Gallaher, R.N. 1977. Soil moisture conservation and yield of crops no-till planted into rye. Soil Sci. Soc. Amer. J. 41:145-147

Gallaher, R.N., and B.J. Brecke. 1998. Base paper for field crops in Florida. IFAS Strategic Planning Conference Proceedings – Florida FIRST, May 20-21, 1999, Safety Harbor Resort and Spa, Safety Harbor, Florida. (IN PRESS).

Gallaher, R.N., and L. Hawf. 1997. Role of conservation tillage in production of a wholesome food supply. pp. 23-31. *In* R.N. Gallaher and R. McSorley (eds.). Proceedings of the 20th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Special Series SS-AGR-60, University of Florida, Gainesville, Florida.

Kells, J.J., and W.F. Meggitt. 1985. Conservation tillage and weed control. *In* F.M. D'Itri (ed.) A systems approach to conservation tillage. Lewis Publishers, Inc., Chelsea, Michigan.

Nissen, O. 1985. Users Guide to MSTAT, Version 4.0. Michigan State University, Lansing, MI.

Phillips, S.H. 1984. No-Tillage Agriculture. p. 1-9. *In* R.E. Phillips and S.H. Phillips (eds.) No-Tillage Agriculture: Principles and Practices. VanNostrand Reinhold Publishing Co., Inc. Quattro Pro, ver. 4.0. 1987. Quattro Pro User's Guide. Scotts Valley, CA: Borland International, Inc.

Soil Survey Staff. 1994. Official soil series description for the Arredondo series. United States Government Printing Office, Washington, DC.

Witt, W.W. 1984. Response of weeds and herbicides under no-till conditions. pp. 152-170. *In* R.E. Phillips and S.H. Phillips (eds.) No-Tillage Agriculture: Principles and Practices. VanNostrand Reinhold Publishing Co., Inc.

Table 1. Control of sicklepod, Texas panicum, and pitted morningglory and cotton (DP 5415 RR) yield as affected by herbicide programs, Gainesville, FL 1998.

Herbicide[1]	Application		Weed Control						Cotton Yield
Treatment	Rate	Timing	CASOB[2]		PANTE		IPOLA		Lint
			Early[4]	Late	Early	Late	Early	Late	
	lb a.i/acre				%				lb/acre
1. Control			0	0	0	0	0	0	189
2. Roundup Ultra	0.75	EPOT[3]	90	75	79	58	76	65	733
3, Roundup Ultra Roundup Ultra	0.75 0.75	EPOT PDS	98	97	98	90	96	94	1168
4. Cotoran(fb) Bladex + MSMA	1.5 0.75 2.0	PRE PDS PDS	93	93	74	42	87	72	686
LSD@0.05	------	------	2.8	9.4	4.9	7.8	8.9	14.2	280

[1]Entire study received preemergence (PRE) application of Roundup Ultra at 2.0 lb a.i./acre plus Prowl at 0.75 lb a.i./acre.
[2]CASOB = sicklepod; PANTE = Texas panicum; IPOLA = pitted morningglory. [3]EPOT = early postemergence over-the-top; PDS = post-directed spray; PRE = preemergence. [4]Early season rating 18 July 1998; Late season rating 22 August 1998.

Table 2. Control of sicklepod, Texas panicum, and pitted morningglory and peanut (Georgia Green) yield as affected by herbicide programs, Gainesville, FL 1998.

Herbicide[1]	Application		Weed Control						Peanut Yield
Treatment	Rate	Timing	CASOB[2]		PANTE		IPOLA		Pod
			Early[4]	Late	Early	Late	Early	Late	
	lb a.i/acre				%				lb/acre
1. Control			0	0	0	0	0	0	819
2. Starfire + Bassgran + surfactant	0.125 0.50	AC[3] AC AC	97	91	87	71	96	93	3285
3. Starfire + Bassgran + surfactant Cadre+ surfactant	0.125 0.50 0.063	AC AC AC POST POST	100	100	100	100	100	100	4067
4. Cadre + surfactant	0.063	POST POST	100	100	91	82	98	100	4139
LSD@0.05	------	------	3.7	4.1	7.2	9.7	3.7	5.4	566

[1]Entire study received preemergence (PRE) application of Roundup Ultra at 0.75 lb a.i./acre plus Prowl at 1.0 lb a.i./acre.
[2]CASOB = sicklepod; PANTE = Texas panicum; IPOLA = pitted morningglory. [3]AC = at-cracking postemergence; EPOST early postemergence over-the-top; POST = postemrgence. [4]Early season rating 18 July 1998; Late season rating 22 August 1998. [5]Induce (non-ionic surfactant) included in mixture at 0.25% v/v.

Table 3. Control of sicklepod, Texas panicum, pitted morningglory, volunteer peanut and soybean (Hartz 7550 RR) yield as affected by herbicide programs, Gainesville, FL 1998.

Herbicide[1]	Application		Weed Control								Soybean
Treatment	Rate	Timing	CASOB[2]		PANTE		IPOLA		ARAHY		Yield
			Early[4]	Late	Early	Late	Early	Late	Early	Late	
	lb a.i/acre		%								Bu Seed/acre
1. Control			0	0	0	0	0	0	0	0	16.0
2. Roundup Ultra	0.75	EPOT[3]	83	80	79	78	86	92	93	97	34.7
3. Roundup Ultra Roundup Ultra	0.75 0.75	EPOT POST	98	100	98	100	98	100	98	100	46.8
Sencor Classic + surfactant	0.38 0.008	PRE POST POST	92	97	67	48	89	95	72	67	36.3
LSD@0.05	------	-------	11.4	5.5	5.0	7.3	4.7	8.7	6.7	6.7	9.7

[1]Entire study received preemergence (PRE) application of Roundup Ultra at 2.0 lb a.i./acre plus Prowl at 0.75 lb a.i./acre.
[2]CASOB = sicklepod; PANTE = Texas panicum; IPOLA = pitted morningglory. [3]EPOT = early postemergence; PRE = preemergence ; POST = postemergence. [4]Early season rating 18 July 1998; Late season rating 22 August 1998. [5]Induce (non-ionic surfactant) included in mixture at 0.25% v/v.

USING DEEP TILLAGE TO IMPROVE YIELDS FROM DRYLAND SOYBEANS: AN ECONOMIC ANALYSIS

A. D. Pearce[1], C. R. Dillon[2], T. C. Keisling[3], C. G. Friddle[4], and M. P. Popp[4]

AUTHORS: [1]Reseach Specialist, Department of Agricultural Economics, University of Arkansas, 221 Agriculture Building, Fayetteville, AR 72701; [2]Associate Professor, University of Kentucky Department of Agricultural Economics, 403 Agricultural Engineering Building, #2, Lexington, KY 40546-0276; [3]Professor, University of Arkansas, Department of Agronomy, Northeast Research and Extension Center, P. O. Box 48 Keiser, AR 72351; [4]Technical Assistant, University of Arkansas, Department of Agricultural Economics and Agribussiness, 221 Agriculture Building, Fayetteville, AR 72701; and [5]Assistant Professor, University of Arkansas, Department of Agricultural Economics and Agribussiness, 221 Argiculture Building, Fayetteville, AR 72701.

REFERENCE: J. E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture*. Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. Research has shown that deep tillage improves yields of dryland soybeans. However, there are increased production costs associated with deep tillage. To examine the economic effects of deep tillage, statistical, breakeven, and sensitivity analyses were performed using yield data from University of Arkansas agronomic experiments conducted from 1995 to 1997. It was hypothesized that the deep tillage treatments result in increased net returns. This was true for the clay soils at Keiser. However, results at Pine Tree were inconsistent, and it was concluded that the least expensive treatment should be used to maximize net returns on silt loam soils.

INTRODUCTION

Deep tillage has been shown to increase yields of dryland soybeans. In a study by Wesley, Smith, and Spurlock (1993), deep tillage under dryland conditions resulted in an average yield increase of 47% when compared to yields from conventional tillage under dryland conditions. This yield effect is associated with increased water intake and profile storage. However, since deep tillage implies an additional expense for the producer, it is necessary to perform an economic analysis to determine the feasibility of such practices. In addition, further study is needed to determine if deep tillage will consistently give such results. As irrigation for soybeans is often not an option for producers, it is necessary to examine methods of increasing net returns from dryland soybean production.

MATERIALS AND METHODS

Deep tillage studies were begun in the fall of 1994 at the University of Arkansas' Northeast Research and Extension Center (NEREC) at Keiser, Arkansas, and the Pine Tree Branch Experiment Station near Colt, Arkansas. Tillage treatments were: (1) conventional shallow tillage twice in late winter or early spring to prepare a seed bed, (2) deep chiseling in fall to a depth of circa 6 inches when the soil was dry, (3) subsoiling in planting direction in fall when soil was dry with hyperbolic subsoiler to a depth of circa 14 to 18 inches, (4) same as treatment number 3 but at a 45 degree angle to planting direction, (5) same as treatment number 3 but performed in late winter or early spring when soil was wet. Treatments were arranged in a randomized complete block design with 8 to 10 replications. Alleys between plots were 29.5 ft wide to give ample room for tillage implements to take the ground prior to entering the plot and to keep machinery out of adjacent plots when leaving the plot and turning. Plots were 49.2 ft by 12.5 ft rectangles except for the 45 degree treatment which was 49.2 ft by 37.4 ft to allow for turning on the sides without trafficking adjacent plots.

The early soybean production system (ESPS) was used since it results in late summer or early fall harvest dates (Heatherley, 1999). This early harvest is necessary so that deep tillage can be done in dry soil before the fall rains. After the tillage treatments were done, no additional tillage treatments were performed until late winter or early spring when normal seed-bed preparation activities occur. Seed-bed preparation consisted of two passes with a field cultivator to loosen the soil, smooth the ground, and apply and incorporate herbicides where appropriate. Other cultural practices were commensurate with Arkansas Cooperative Extension Service recommendations.

Soybean yield (adjusted to 13% moisture) was calculated from strips harvested from the center of each plot. Yield data were analyzed statistically using the General Linear Models (GLM) procedure in the Statistical Analysis System (SAS).

Economic analyses are based on enterprise budgets generated by the Mississippi State Budget Generator (MSBG). An enterprise budget was generated for each year for each tillage treatment, year, and location combination utilized in the study. Due to the number of replications in the experiment, MSBG was used to calculate only direct and fixed expenses, while net returns were calculated using a spreadsheet. A five year (1993 - 1997) average of the statewide soybean price of $6.72/bu was used to calculate gross receipts. Price data were taken from various issues of the *Arkansas Agricultural Statistics* (Arkansas Agricultural Statistics Service, 1996, 1997, 1998). This average price was used to eliminate any market effects due to years with abnormally high or low prices. The input prices included in the version of MSBG issued by the Arkansas Cooperative Extension Service for 1997 were used for the field operations.

For budgeting purposes, all treatments utilized a machinery complement consisting of a 29.58 ft field cultivator pulled by a 200 hp tractor, a 20 ft grain drill pulled by a 145 hp tractor, a 47 ft broadcast sprayer pulled by a 145 hp tractor, a 1000 gallon water tank pulled by a 3/4 ton pickup, an 8 ft furrow ditcher pulled by a 145 hp tractor, and a 20 ft soybean combine. Fall and spring subsoiled treatments also utilized a 12 ft, seven shank subsoiler. Deep chiseled plots used a 17 ft chisel plow, and paratill treatments utilized a 15 ft, six shank paratill implement. All deep tillage implements were drawn by 225 hp tractors.

The GLM procedure in SAS was used to determine the significance of the various treatments used in the agronomic experiment. A model using tillage treatment, replication, year, year by replication interaction, and tillage treatment by year interaction as explanatory variables was used to analyze the dependent variables, which were yields, and net returns above total expenses (see Table 1). Duncan's Multiple Range Test was used to rank the various production systems by determining least significant differences across treatments.

Breakeven and sensitivity analyses were conducted in order to gain a broader perspective of the economic implications of the various tillage, planting, and herbicide combinations. Breakeven analysis was conducted for prices and yields above both direct and total expenses, while sensitivity analysis was conducted using soybean prices which were 10% and 25% higher and lower than the five year average price of $6.72/bu.

RESULTS AND DISCUSSION

Statistical analysis (Table 1) showed that at Keiser, year and tillage treatment were statistically significant at the .01 level, while replication and the replication by year interaction were significant at the .05 level. The year by tillage treatment interaction was not statistically significant. Based on this analysis, year and tillage treatment were the main causes of yield effects. Since this was a designed experiment, the significance of replication was expected and is therefore ignored.

Statistical analysis for yields at Pine Tree showed that replication, year, and the replication by year interaction were all significant at the .01 level. Again, replication was expected to be significant and is ignored. Tillage treatment was significant at the .10 level, while the year by treatment interaction was not statistically significant.

Statistical analysis for net returns above total expenses at Keiser showed replication to be statistically insignificant, while year was significant at the .01 level. The year by replication interaction was significant at only the .10 level. Tillage treatment was significant at the .05 level, but the year by treatment interaction was again not statistically significant.

The same analysis for Pine Tree showed replication, year, and the year by replication interaction to be significant at the .01 level. Tillage treatment was only significant at the .10 level for net returns above total costs. The tillage treatment by year interaction was also not statistically significant for net returns at the Pine Tree location.

Yields at the Keiser location were considerably higher than those at the Pine Tree location, as can be seen in Table 2. Duncan's Multiple Range Test showed that only 1995 was significantly different among years at Keiser, while significant differences between tillage treatments were somewhat more complex. All three years were significantly different at Pine Tree, and only spring subsoiling and chisel plowing were significantly different from each other. All Duncan groupings are shown in Table 2.

Given the higher yields at Keiser, net returns were consistently higher at that location. Duncan results for net returns above direct expenses and net returns above total expenses were identical to those for yields. Net returns above direct expenses and net returns above total expenses are shown in Tables 3 and 4, respectively.

Sensitivity analysis (Table 5) showed net returns above total costs to be highly sensitive to changes in price. At Keiser, a 10% change in soybean price resulted in a 14 - 19% change in net returns above total costs, depending on year and tillage treatment. A 25% change in price resulted in 35 - 49% change in net returns above total costs, depending on year and tillage treatment. The results for Pine Tree were far more erratic. There, a 10% change in price resulted in a 11- 470% change in net returns above total costs, depending on year and tillage treatment, while a 25% change in price resulted in a 28 - 1178% change in net returns above total costs. This is attributable to the yield differentials between locations, since cost structures are similar for both Pine Tree and Keiser. Direct and total expenses are shown in Tables 6 and 7, respectively.

Fall deep tillage (subsoil dry) at Keiser had the lowest breakeven prices (Table 8) above direct costs in 1995 and 1996, while conventional tillage had the lowest in 1997. Breakeven prices above total costs were lowest for conventional tillage in 1995 and 1997, and for fall deep tillage (subsoil dry) in 1996. Results show that breakeven prices above direct and total expenses are higher for the

Pine Tree location than for the Keiser location. This can again be attributed to the lower yields at Pine Tree. Breakeven prices above both direct and total expenses at Pine Tree were lowest for fall deep tillage (subsoil dry) in 1995, for conventional tillage in 1996, and for deep chiseling in 1997. Breakeven yields, however, were similar for both locations, due to the similar cost structures. Breakeven yields are shown in Table 9. In all cases conventional tillage consistently had the lowest breakeven yields above direct and total expenses.

Given that fall deep tillage gave the highest yields and net returns in two out of three years at Keiser, and that yields and net returns from fall deep tillage are significantly different from yields and net returns of other treatments, it may be concluded that it is a viable practice under heavy soil conditions such as are found at Keiser. However, at Pine Tree, there are inconsistent results across years and treatments, and only deep chisel plowing and spring deep tillage (subsoil wet) are not significantly different from one another. Therefore, one may conclude that the least expensive treatment should be used to maximize net returns on silt loam soils such as those found at Pine Tree. This would be consistent with the findings of other studies that determined that deep tillage increases yields by eliminating mechanical impedances to root growth, which facilitates moisture uptake (Wesley and Smith, 1991; Wesley, Smith, and Spurlock, 1993).

REFERENCES

Arkansas Agricultural Statistics Service. 1996. Arkansas Agricultural Statistics for 1995. Arkansas Agricultural Experiment Station, Report Series 334.

Arkansas Agricultural Statistics Service. 1997. Arkansas Agricultural Statistics for 1996. University of Arkansas Cooperative Extension Service, Miscellaneous Publication 393.

Arkansas Agricultural Statistics Service. 1998. Arkansas Agricultural Statistics for 1997. University of Arkansas Cooperative Extension Service, Miscellaneous Publication 400.

Heatherley, L. G. 1999. Early soybean production system (ESPS). *In* L. G. Heatherley and H. F. Hodges (eds.) Soybean production in the Midsouth. pp. 103-118.

Wesley, R. A., and L. A. Smith. 1990. "Response of Soybean to Deep Tillage With Controlled Traffic on Clay Soil." Transactions of the ASAE, 34: 113-119.

Wesley, R. A., L. A. Smith, and S. R. Spurlock. 1993. "Economic Analysis of Irrigation and Deep Tillage in Soybean Production on Clay Soil." Soil and Tillage Research, 28: 63-78.

Table 1: Statistical Analysis of Yields and Net Returns at Pine Tree and Keiser, 1995 - 1997

Section I: Pine Tree		Yield Model	Net Returns Above Total Costs Model	
Model	F Value	Pr > F	F Value	Pr > F
EDF = 89	7.22	0.0001	6.05	0.0001
Variables	F Value	Pr > F	F Value	Pr > F
Replication	6.05	0.0001	3.59	0.0007
Year	71.90	0.0001	65.20	0.0001
Year X Replication	2.50	0.0040	2.29	0.0083
Treatment	2.24	0.0896	2.35	0.0779
Year X Treatment	1.70	0.1310	1.25	0.2873
Section II: Keiser		Yield Model	**Net Returns Above Total Costs Model**	
Model	F Value	Pr > F	F Value	Pr > F
EDF = 104	7.18	0.0001	3.44	0.0001
Variables	F Value	Pr > F	F Value	Pr > F
Replication	2.32	0.0190	1.56	0.1361
Year	89.45	0.0001	35.72	0.0001
Year X Replication	1.72	0.0508	1.52	0.0996
Treatment	9.29	0.0001	2.78	0.0446
Year X Treatment	1.44	0.2060	1.24	0.2932

Note: EDF = Error Degrees of freedom Pr>F=Probability of F value

Table 2: Yield (Bu/acre)* at Pine Tree and Keiser, 1995 - 1997

	Conventional Tillage	Deep Chisel	Subsoil Dry	Subsoil Wet
Pine Tree	(a, b)	(a)	(a, b)	(b)
1995 (b)	15.77	15.78	19.50	13.59
1996 (c)	11.42	12.03	10.66	11.58
1997 (a)	24.15	27.26	24.29	23.50
Keiser	(b, c)	(c)	(a)	(a, b)
1995 (b)	35.39	35.02	39.96	37.82
1996 (a)	47.55	47.93	59.44	49.76
1997 (a)	53.09	45.42	52.20	53.34

* Letters in parentheses represent results from Duncan's Multiple Range Test. Years and treatments with the same letter are not significantly different.

Table 3: Net Returns above Direct Costs ($/acre) at PineTree and Keiser, 1995 - 1997

Pine Tree	Conventional Tillage	Deep Chisel	Subsoil Dry	Subsoil Wet
1995	38.41	34.66	54.37	14.98
1996	(2.79)	(4.02)	(17.06)	(10.55)
1997	87.82	104.83	79.58	74.62
Keiser				
1995	155.38	149.05	176.92	162.91
1996	245.66	242.91	316.47	251.73
1997	274.71	219.46	259.70	267.66

Table 4: Net Returns above Total Costs ($/acre) at Pine Tree and Keiser, 1995 - 1997

Pine Tree	Conventional Treatment	Deep Chisel	Subsoil Dry	Subsoil Wet
1995	4.59	(2.25)	12.87	(26.52)
1996	(42.42)	(47.93)	(64.36)	(57.85)
1997	55.73	69.66	39.82	34.86
Keiser				
1995	131.12	121.70	144.98	130.97
1996	221.13	214.10	284.27	219.53
1997	243.81	185.82	221.47	229.43

Table 5: Price Sensitivity Analysis for Pine Tree and Keiser, 1995 - 1997

	% change in net returns above total costs at prices 10% higher and lower than average			
Pine Tree	Conventional Tillage	Deep Chisel	Subsoil Dry	Subsoil Wet
1995	±30	±470	±99	±134
1996	±18	±17	±11	±13
1997	±29	±26	±41	±45
Keiser				
1995	±18	±19	±18	±19
1996	±14	±15	±14	±15
1997	±15	±16	±16	±16
	% change in net returns above total costs at prices 25% higher and lower than average			
Pine Tree	Conventional Tillage	Deep Chisel	Subsoil Dry	Subsoil Wet
1995	±577	±1178	±255	±86
1996	±45	±42	±28	±34
1997	±73	±66	±102	±113
Keiser				
1995	±45	±48	±46	±49
1996	±36	±38	±35	±38
1997	±37	±41	±40	±39

Table 6: Direct Expenses ($/acre) at Pine Tree and Keiser, 1995 - 1997.

Pine Tree	Conventional Tillage	Deep Chisel	Subsoil Dry	Subsoil Wet
1995	67.53	71.38	76.68	76.36
1996	79.55	84.89	88.70	88.39
1997	74.48	78.33	83.62	83.31
Keiser				
1995	82.44	86.29	91.59	91.27
1996	73.85	79.17	83.00	82.68
1997	82.08	85.79	91.08	90.77

Table 7: Total Expenses ($/acre) at Pine Tree and Keiser, 1995 - 1997.

Pine Tree	Conventional Tillage	Deep Chisel	Subsoil Dry	Subsoil Wet
1995	101.35	108.29	118.18	117.86
1996	119.18	128.80	136.00	135.69
1997	106.57	113.50	123.38	123.07
Keiser				
1995	106.70	113.64	123.53	123.21
1996	98.38	107.98	115.20	114.88
1997	112.98	119.43	129.31	129.0

Table 8: Breakeven Prices for Pine Tree and Keiser, 1995 - 1997.

	Above direct expenses ($/bu)				Above total expenses ($/bu)			
Pine Tree	Conventional Tillage	Deep Chisel	Subsoil Dry	Subsoil Wet	Conventional Tillage	Deep Chisel	Subsoil Dry	Subsoil Wet
1995	4.28	4.52	3.93	5.62	6.43	6.86	6.06	8.67
1996	6.97	7.06	8.32	7.63	10.44	10.71	12.76	11.72
1997	3.08	2.87	3.44	3.55	4.41	4.16	5.08	5.24
Keiser								
1995	2.33	2.46	2.29	2.41	3.01	3.25	3.09	3.26
1996	1.55	1.65	1.40	1.66	2.07	2.25	1.94	2.31
1997	1.55	1.89	1.74	1.70	2.13	2.63	2.48	2.42

Table 9: Breakeven Yields for Pine Tree and Keiser, 1995 - 1997

	Above direct expenses (bu/acre)				Above total expenses (bu/acre)			
Pine Tree	Conventional Tillage	Deep Chisel	Subsoil Dry	Subsoil Wet	Conventional Tillage	Deep Chisel	Subsoil Dry	Subsoil Wet
1995	10.05	10.62	11.41	11.36	15.08	16.11	17.59	17.54
1996	11.84	12.63	13.20	13.15	17.74	19.17	20.24	20.19
1997	11.08	11.66	12.44	12.40	15.86	16.89	18.36	18.31
Keiser								
1995	12.27	12.84	13.63	13.58	15.88	16.91	18.38	18.33
1996	10.99	11.78	12.35	12.30	14.64	16.07	17.14	17.10
1997	12.21	12.77	13.55	13.51	16.81	17.77	19.24	19.20

CRIMSON CLOVER-COTTON RELAY CROPPING WITH CONSERVATION TILLAGE SYSTEM

Sharad C. Phatak[1], Rick Reed[2], Wayne Fussell[3], W. Joe Lewis[4], and Glen H. Harris[5]

AUTHORS: [1]University of Georgia, P.O. Box 748, Tifton, GA 317943-0748; [2]University of Georgia, Cooperative Extension Service, Douglas, GA 31533; [3]Conway Vickers Road, Ambrose, GA 31512; [4]USDA-ARS, P.O. Box 748, Tifton., GA 31794; [5]University of Georgia, P.O. Box 1209, Tifton, GA 31794
Corresponding Author: S.C. Phatak; E-mail: phatak@tifton.cpes.peachnet.edu
REFERENCE: J. E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. In research trials, 'Relay-Cropping System' of two cover crops with conservation tillage was compared with a conventional production system for cotton using all recommended practices, during 1991-92 and 1992-93. Three cover crops: Crimson clover (*Trifolium incarnatum* L.`Dixie'), subterranean clover (*Trifolium subterraneum* L. 'Mt. Barker'), and rye (*Secale cereale* L. 'Wrens Abruzzi') were planted in November, 1991 and again in November, 1992. Crimson clover and subterranean clover plots were strip-killed with glyphosate (Roundup) in mid-April and then planted no-till in dead strips, two weeks later. For conventional production, rye plots were harrowed and deep-turned with moldboard plow. Cotton (*Gossipium hirsutum* L.) was planted with modified no-till John Deere 71 planters. No fertilizers or insecticides were applied to no-till 'Relay Cropping System' plots with crimson and subterranean clover. Relay plots produced significantly higher yields than conventional plots during both years.

A grower field of 7.2 acres was planted with 'Dixie' crimson clover in Fall, 1993. Clover has re-seeded every year since then. Five crops of cotton were raised from 1994 to 1998. Cotton was strip-till planted for first four years and 1998, it was planted with a no-till planter. No insecticides were used for producing these five crops. Only starter solution and nitrogen fertilizers were used during first four years and in addition, sulfate of potash-magnesia was also applied in 1998. In spite of substantial reduction in inputs this non-irrigated field produced cotton yields above the state average during all five years. Thus, 'Relay-Cropping System' which is environmentally friendly, socially acceptable, and economically feasible offers an alternative production system to a conventional production system.

INTRODUCTION

Increasing concerns about environment and farm profitability led scientist to research alternative systems which are less reliant on off-farm chemical inputs. Many sustainable crop production systems with emphasis on 'Total System' have been researched for a variety of vegetable and field crops (Brunson, 1991, Phatak, 1992, 1994, 1998). Conservation tillage and cover crops were key components in all these alternative systems. Two major barriers to adaptation of the alternative systems have been decreased yields and specific pest problems. Yield reduction made many alternative systems less attractive for most crops. A prime crop example having specific problem was boll weevil in cotton production in the southeastern United States.

The Georgia Boll Weevil Eradication Program (BWEP) was initiated in 1987 with boll weevil population severely depressed by 1990 (Lambert, 1991). By 1992, boll weevil was essentially eradicated in Georgia. The success of BWEP dramatically reduced the total number of insecticide sprays required for cotton production. Encouraged by the success of the BWEP, researchers and cotton producers diverted their interests towards evaluating alternative systems to further reduce off-farm pesticide and fertilizer inputs. Researchers and growers had been studying alternative systems which reduced tillage, fertilizer and pesticide inputs (Phatak, 1992, 1994; Leidner, 1994; Bugg et al., 1991; Phatak et al., 1991; Yancy, 1994, 1996). Information from on-going research on sustainable production of vegetable and agronomic crops with cover crops, reduced tillage, reduced fertilizers and reduced pesticides was useful in developing alternative production strategies for cotton production. Strategies for 'Relay-Cropping System' has been outlined (Bugg et al., 1991; Phatak ,1993). Thus, research was conducted to evaluate relay-cropping with conservation tillage and cover crops for cotton production in 1991-92 and 1992-93. A number of field plots were established in Fall, 1993, after successful completion of 'No-Till Relay System' research. This paper presents results of research trials and data from a grower's field plot that has been in cotton production for five years with the 'Crimson Clover-Cotton Relay System.' In this paper more emphasis is placed on soil fertility, nutrient management, and recycling.

MATERIALS AND METHODS

Research Trials

'No-Till Relay System' with crimson and subterranean clovers was compared with conventional tillage system with rye cover crop. Field studies were conducted during 1991-92 and 1992-93 at the Horticulture farm, at the

Coastal Plain Experiment Station, College of Agricultural and Environmental Sciences, University of Georgia, Tifton. Three cover crops: Crimson clover (*Trifolium incarnatum* L.`Dixie'), subterranean clover (*Trifolium subterraneum* L. 'Mt. Barker'), and rye (*Secale cereale* L. 'Wrens Abruzzi') were planted in November, 1991 and again in November, 1992. Plots were 50' long and 36' wide (6 beds, 6' wide). Randomized complete block with four replications was used during both years. Crimson and subterranean clover plots were strip-killed with glyphosate (Roundup) mid-April and then planted no-till in dead strips, two weeks later. For conventional production, rye plots were harrowed and deep-turned with a moldboard plow. Cotton (*Gossipium hirsutum* L.) was planted with modified no-till John Deere 71 planters. No fertilizers were applied to no-till plots with crimson clover and subterranean clover. All plots were irrigated as needed to average at least 1" per week.

No soil applied or foliar insecticides were used in no-till relay systems. In the 'Conventional System' Temik (7.0 lb/acre of 15G) was used for control of thrips and nematodes. Cotton in the conventional system also received six foliar applications of insecticides to control whiteflies, aphids, fall armyworms, and beet armyworms. For insect control in conventional plots, insecticides applied included one application of Monitor (1 pt./A), two applications of Lorsban (1 pt./A), two applications Lannate (2 pts./A) and one application of Ambush (12 oz./A).

For weed control, as mentioned above, only Glyphosate was applied two weeks before planting in no-till relay system plots. Areas between rows in no-till plots were mowed with a flail mower, 6-8 weeks after planting. Trifluarlin (treflan ½ lb/acre) was preplant incorporated for weed control in conventional plots. For full season weed control, conventional plots were cultivated and layby directed treatment of MSMA (2.5 pts./A) plus cotoron (1.5 qts./A) was applied six weeks after planting.

Grower's Field Plot

Research results with 'No-Till Relay Systems' were very encouraging, therefore, 15 lb/acre of crimson clover was planted in 7.2 acres in Coffee county during November, 1993. Crimson clover has re-seeded in this field from 1994 to 1998. From 1994-1997 (four years) the field was strip-tilled and planted with cotton during late April to mid-May. In 1998 cotton was planted with a no-till planter. Cotton cultivar DPL-90 was planted during the five years of this investigation.

Soil test results are presented in Table 2. To promote better seedling growth in furrow treatment, a 'Starter Solution' of 100 lb/acre of 10-34-0 was applied at planting during all five years and side-dressed with 200 lb ammonium nitrate per acre at bloom during 1994-98 (four years). In 1998, 300 lb of sulfate of potash-magnesia (sulpomag) was applied in addition to 200 lb of ammonium nitrate at bloom. This field was monitored by scouts regularly.

Weed control treatments were: glyphosate (Roundup), sprayed in 12 in. bands, two weeks prior to planting. Cotoron and Prowl were applied at planting and Bladex plus MSMA were applied 6 weeks after planting with hooded sprayer.

RESULTS AND DISCUSSION

Research Trials

Data from research studies conducted at the Coastal Plain Experiment Station has been summarized in Table 1. Crimson and subterranean clover were alive at the time cotton was planted. Crimson clover matured and died in late May and subterranean clover in mid-June. Subterranean clover was difficult to kill with herbicide glyphosate. Cotton plants in the no-till system were short with short internodes and produced bolls on the lowest branches. When compared with 'Conventional Systems' yield increase following crimson and subterranean clover under 'Relay Cropping System' was highly significant.

Very high numbers of beneficial insects were found in this field during two growing seasons in clover-cotton relay research plots. Pest insects were below threshold in these plots, therefore, no insecticides were applied to clover-cotton relay plots. Beneficial insect population was minimal and pest insect population was high in the conventional system. Insecticidal treatments were needed for white flies, aphids, fall armyworms, and beet armyworms.

Growers Field Plot

Encouraged by the success of these clover-cotton relay cropping systems at the research level a number of field plots were established in Fall, 1993. Data presented in tables 2, 3 and 4 are from one of these field plots that has been in continuous clover-cotton relay system since planting of clover in Fall, 1993.

Data presented shows that this 7.2 acre field produced higher cotton yields than state average during all five years. The state average includes irrigated cotton, also, while this was dryland cotton. Thus, this higher yield is even more significant. This 7.2 acre field showed no sign of water stress even during driest season. Overall crop growth was normal during all five years.

Pest Management

Thrips population in this field was low in spite of the fact Temik was not applied to this field. Pest insect population was low during five growing seasons and no insecticide applications were made. Few insects may be due to higher populations of beneficial insects observed in this field during all five cropping season. Scouting indicated no need for insecticide application during all years. Most conventional cotton growers applied Temik and made an average of 3.5 insecticide applications each season to grow cotton during last five growing seasons.

Nutrient Removal

Nutrient removal was calculated by using data obtained from Zublena (1991) and presented in Table 4. Nitrogen removed by harvested seed cotton ranged from 48.73 to 61.74 lb/acre with an average removal of 55.94 lb/acre per year. Nitrogen application each year was about 70 lb/acre with most of it removed by the harvested crop. Conventional cotton growers apply 90 lb/acre to obtain similar yield. There was a reduction of 20 lb/acre of nitrogen in relay system compared with conventional production. In the research trials reported above, no fertilizer was applied to relay system cotton. In recent research there was no yield response to nitrogen with a clover relay system. Clover also added nitrogen to the fields. The amount of nitrogen added by a crop of clover varies greatly and depends upon the growth of the clover. Further research is needed to evaluate cotton response to nitrogen rates in a clover system.

Phosphorus removed by the cotton crop ranged from 19.34 to 25.50 lb/acre with an average removal of 22.39 lb/acre per year. The amount of phosphorus applied each year was 34 lb/acre with a total of 170 lb/acre during five years. Thus, 65.9% phosphorus applied was removed from the field by harvested crop. Conventional growers generally use the same amount of phosphorus as a starter solution.

Harvested cotton removed between 30.38 to 23.98 lb/acre of potassium with an average removal of 27.52 lb/acre per year. Total amount of potassium removed by harvested crop was 137.59 lb/acre during five years. While only 78 lb/acre was applied in 1998. It appears that clover crop is recycling and redistributing potassium from soil layer below sampling zone. Soil test results (Table 2) clearly demonstrate this redistribution.

During five years, harvested cotton crop removed a total of 17.77 lb/acre of calcium, 31.07 lb/acre magnesium, 22.20 lb/acre of sulfur, 0.80 lb/acre copper, 1.47 lb/acre of manganese, and 4.26 lb/acre of zinc. Of these nutrients 15 lb/acre of magnesium as sulfate of potash-magnesia (sulpomag) was applied in 1998. Sulfur was also applied as sulfate of potash-magnesia (sulpomag).

Nitrogen, potassium, magnesium, sulfur, and boron leach in sandy/sandy loam soils with low organic matter. Theoretically, if leaching is eliminated or substantially reduced it should be possible to maintain soil fertility at optimum levels by applying nutrients that have been removed by harvested crops. Clover-cotton relay cropping system with cover crops and conservation tillage has achieved this to some extent.

Soil analysis showed a substantial increase of phosphorus, potassium, calcium, magnesium, zinc, and manganese in top soil 4-5 months after planting clover. It appears that clover redistributed nutrients from below soil sampling zone to the sampling zone.

CONCLUSIONS

In 'Relay Cropping Systems' with legume cover crops and conservation tillage, cotton crops were grown with reduced fertilizer inputs and insecticide applications were not needed. Thus, these systems are economically feasible and environmentally friendly. More large scale adaptation is needed to understand weaknesses and strengths of these systems.

REFERENCES

Anonymous. 1998. 1999 Cotton Production Guide. Publication CSS-99-07, Cooperative Extension Service/The University of Georgia, College of Agricultural and Environmental Sciences, November, Page 2.

Brunson, K.E. 1991. Winter cover crops in the integrated pest management of sustainable cantaloupe production. MS Thesis, University of Georgia, Athens, Georgia.

Bugg, R.L., F.L. Wackers, K.E. Brunson, J.D. Dutcher, and S.C. Phatak. 1991.Cool-Season Cover Crops Relay Intercropped with Cantaloupe: Influence on a Generalist Predator, *Geocoris punctipes* (Hemipter: Lygaeidae). Journal of Economic Entomology 84:408-416.

Lambert, W.R. 1991. The Southeastern Boll Weevil Eradication Program: Extension Perspective. Paper presented at the 1991 Beltwide Cotton Conference in San Antonio, Texas.

Leidner, John. 1994. No-Till has a Place in Vegetables. Progressive Farmer, September, Page 26.

Phatak, S. C. 1992. An integrated sustainable vegetable production system. HortScience 27:738-741.

Phatak, S.C. 1993. Legume cover crops-cotton relay cropping systems. Proc. 2nd Organic Cotton Conference, September. Compiled and edited by the California Institute for Rural Studies, Davis CA, pp. 280-285.

Phatak, S.C. 1994. A no/low pesticide system for vegetables." Proc. 8th North Carolina Vegetable Expo, January 10-12, Raleigh, North Carolina, pp. 75-76.

Phatak, S.C. 1998. Managing pests with cover crops, pp. 25-33. In: Managing Cover Crops Profitably. 2nd Edition, Sustainable Agricultural Network, Handbook Series Book 3. Sustainable Agriculture Research and Education Program of CSREES, USDA, National Agricultural Library, Beltsville, MD 20705-2351.

Phatak, S.C., R.L. Bugg, D.R. Sumner, J.D. Gay, K.E. Brunson, and R.B. Chalfant. 1991. Cover Crop Effects on Weeds, Diseases, and Insects of Vegetables. Hargrove, W.L., Editor, Cover Crops for Clean Water, Proc. International Conf., West Tennessee Experiment Station, Jackson, Tennessee, April 9-11, Published by the Soil and Water Conservation Society, pp. 153-154.

Yance. C. 1994. Covers challenge cotton chemicals. The New Farm, pp. 20-23. (Magazine of Regenerative Agriculture. Rodale Institute, Red Oak, IA 51591-0306).

Yance, C. 1996. Reduce costs with change to spare. The Peanut Farmer, pp. 10-12. (Specialized Agricultural Publications, Inc. Raleigh, NC 27604).

Zublena, J.P. 1991. Soil facts, nutrient removal crops in North Carolina. The North Carolina Extension Service, North Carolina State University, Raleigh, NC. Publication No. AG-439-16, March.

Table 1. Comparison of Relay-cropped and Conventional Cotton, Tifton, Georgia.

Treatment	1992	1993	Total	Average
Crimson clover	5558 a**	5374 a	10932 a	5466 a
Subter. clover	5215 a	5109 a	10324 a	5162 a
Conventional	1659 b	1889 b	3548 b	1774 b

** Means within columns, followed by same letter not significantly different (Duncan's Multiple Range Test, p=0.01).

Table 2. UGA Soil Test Report Summary for 1993 to 1998 for Crimson Clover/Cotton Field (7.2 acre) of Wayne Fussell, Ambrose, Georgia (Coffee County).

Year/Month	P	K	Ca	Mg	Zn	Mn	pH
				lb/acre			
1993/Jan.	32 M	92 M	431	43	1	8	6.3
1994/Feb.	76 H	160 M	869	83	5	23	6.1
1995/Mar.	71 H	138 M	830	78	2	19	6.2
1996/Feb.	67 H	115 M	801	73	1	13	6.3
1997/Feb	59 M	95 M	665	66	1	17	6.1
1998/Apr.	47 M	65 L	495	58	1	20	5.6

Table 3. Yield of Cotton from 1994-1998 from 'Clover/Cotton Relay Cropping' Field (7.2 acre).

Year	Seed cotton	Bales	Lint	Seed	Seed Value	Lint/acre	State Avg.
			lb	lb	$	lb	lb/acre
1994	18345	14	7097	9785	440.33	985.69	843
1995	14480	10	4790	5880	274.35	665.28	644
1996	17520	14	6910	9260	416.70	959.72	747
1997	15820	10	4790	6477	339.52	665.28	646
1998	16920	12	6108	8369	439.37	848.33	500

Table. 4. Nutrient Removal (lb/acre) by Seed Cotton Harvested During 1994-1998.

Year	Yield	N	P_2O_5	K_2O	Ca	Mg	S	Cu	Mn	Zn
1994	18345	61.74	25.50	30.38	3.92	6.86	4.90	0.18	0.32	0.94
1995	14480	48,73	19.34	23.98	3.09	5.41	3.87	0.14	0.26	0.74
1996	17520	59.07	23.40	29.01	3.74	6.55	4.68	0.17	0.31	0.90
1997	15820	53.24	21.13	26.20	3.40	5.92	4.23	0.15	0.28	0.81
1998	16920	56.94	22.60	28.02	3.62	6.33	4.52	0.16	0.30	0.87
Removed	Total	279.72	111.97	137.59	17.77	31.07	22.20	0.80	1.47	4.26
	Avg.	55.94	22.39	27.52	3.55	6.21	4.44	0.16	0.29	0.85
Applied	Total	350.00	170.00	78.00		15.00	5.00			
	Avg.	70.00	34.00	15.60		3.00	1.00			

EVALUATION OF THE ADAPTATION OF ULTRA-SHORT SEASON CORN FOR THE MID-SOUTH

T.C. Keisling[1], H.J. Mascagni, Jr.[2], A.D. Cox[3], and E.C. Gordon[3]

AUTHORS: [1]Professor, University of Arkansas, Northeast Research and Extension Center, P. O. Box 48, Keiser, AR 72351; [2]Associate Professor, Louisiana State University, Northeast Research Center, St. Joseph, LA;[3] Research Specialists, University of Arkansas, Northeast Research and Extension Center, Keiser, AR.
REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tifton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. Soils in the South are thin and low in organic matter. Summer crops suffer from drought in the summer after stored soil water is depleted. Summer crops that grew and matured prior to the depletion of the stored soil water could avoid this drought stress. They could also provide a high residue grass crop for rotation if they were corn or grain sorghum. Some ultra-short season corns have been developed commercially for the extreme northern corn belt. Experiments to investigate cultural practices and growth habits of ultra-short season corn were conducted in Arkansas and Louisiana. Results indicate that plant population needs to be higher than that used in full-season corns. Planting early on narrow rows results in some inherent problems with fertility; especially post planting N. Plant maturity measurements indicate that ultra-short season corn can mature early enough for drought avoidance while producing an acceptable yield. However, other characteristics such as disease tolerance, shuck cover, etc. may not be suitable for production in the region. Continued selection and production practice evaluation are needed before this can be a recommended practice.

INTRODUCTION

The Southeastern United States has a humid climate receiving in excess of 40 in. of rainfall annually (Bruce et al., 1980). This would be an abundant supply, except most of it comes during the winter months. Many of the soils in the region are shallow and have low water storage capacity (Buol, 1973). There are about 15,000,000 acres that fit this category. Crops grown in the region usually possess some degree of drought tolerance. The management or cropping system used is an integral component of producing a profitable crop.

One relatively recent innovation in the region has been early soybean production systems (ESPS) (Heatherley, 1999). In certain areas and on certain soil types this has been very successful. For other areas and soil types, it has been less than successful. The reason for its success or failure for dryland production appears to be a combination of climate and stored extractable soil water. If the combination of these two factors is sufficient to avoid the major soil droughts by maturing early, then the system is very successful; otherwise, it can be a drastic failure. Since a large part of the region consists of soils with lower water storage capacity (3 to 4 inches), growing the ESPS soybeans on them can be a risk.

Looking at alternative crops with similar drought avoidance strategies brings to mind cool season crops such as the cereal crops of wheat, oats, barley, and rye, or an oilseed, such as rapeseed. These do well in avoiding droughts but have other problems associated with them such as disease susceptibility, lack of winter hardiness, the lack of a ready market, or the lack of economically sustainable production. These crops do avoid droughts in the region well. Examining other warm season grain crops suggests corn or grain sorghum. These crops have traditionally been grown as full-season crops. In the case of dryland corn this has meant planting at low populations to conserve soil moisture for critical growth stages. Grain sorghum is much more drought tolerant than corn and is preferred for dryland production in many cases. However, the yield of both crops is drastically reduced under drought conditions.

The current dryland cotton and soybean crops do not return sufficient residues to the soil surface to prevent erosion or to provide a source of carbon for the rapid building of organic matter. A high residue crop with stover having a high C:N ratio would fill a much needed niche here (Denton et al., 1995; Langdale et al., 1995a; Langdale et al., 1995b; and Keisling et al.,1995).

Ultra-short season cultivars (i.e. those having maturity dates of 75 to 90 days) have been developed for corn and grain sorghum. The corn was developed for the extreme northern corn belt, but cultivars that would mature at approximately the same time as winter wheat could make an attractive alternative crop for the southern region of the United States. Winter wheat could mature from the first week in May to the first week in July depending on the location, variety, and year. These crops have a ready market in the region, may avoid droughts almost as well as cool season crops, provide a much needed high residue producing monocot for crop rotation, and if yields are high enough can be economically sustainable. Thus, it appears that there exists good potential for their adaptation.

Experiments were done in Arkansas in 1998 and in Louisiana in 1994 and 1995 to assess the current potential of ultra-short season corn for the region and to observe its growth characteristics.

MATERIALS AND METHODS

Arkansas

Several cultivars were obtained to test in a population by N fertility test. The experimental design was a stripped-stripped-split plot with two replications. Main plots for one set of strips were varieties with sub-plots being populations of 40,000, 50,000, and 60,000 plants per acre. Stripped across the test perpendicular to the varieties were N rates of 175,250, and 325 lbs. N per acre. This test was conducted as a dryland test at Keiser, AR, on a sandy, silty clay and at Pine Tree, AR, on a Calloway silt loam. Another test at Pine Tree was irrigated. Cultivars used in the tests at both locations were 'Cargill 1877' and 'Cargill 2427'. The tests were planted the first time on April 6 at Keiser and April 7 at Pine Tree. The tests were replanted on May 5 at both locations. Treatments remained the same at Keiser. However, 'Cargill 2427' and 'Cargill 1877' were replanted in the irrigated trial at Pine Tree, and the populations were 40,000 and 60,000 plants per acre. The dryland test at Pine Tree was planted only with 'Cargill 2427' at 40,000 and 60,000 plants per acre. Weed control measures were according to recommended guidelines for pre-emergence herbicides. A multi-population, dryland grain sorghum test was planted on May 5 in conjunction with the dryland ultra-short season corn test at Pine Tree for comparison. Planting equipment, weed control, and fertilizer applications for the grain sorghum were the same as those for corn. In addition, a small cultivar test was conducted at Keiser to observe the growth of other commercially available ultra-short season corn cultivars.

The test at Keiser was planted each time with a John Deere drill with 7.5-in. row spacing. Plot size was 10-ft wide by 60-ft long. The first planting at Pine Tree was done with a Marliss drill on 7.5-in. row spacing, and the plot size was 10-ft wide by 60-ft long. The replanting was done with a John Deere drill on 7.5-in. row spacing, and the plot size was 15-ft by 60-ft.

Prior to the first planting, fertilizer, 50-80-80 (N-P_2O_5-K_2O) per acre, was applied over the test areas with a ground driven spreader. The N strip treatments were applied at Keiser on May 29 when corn was at the 6-leaf stage and at Pine Tree on June 8 when corn was in the 8-leaf stage with a tractor mounted, PTO-driven spreader.

Louisiana

Field experiments were conducted in 1994 and 1995 on a Sharkey clay (very fine, montmorillonitic, nonacid, thermic Vertic Haplaquepts) at the LSU Agricultural Center's Northeast Research Station near St. Joseph, LA, to evaluate hybrid maturity at two planting dates. Nine hybrids were evaluated. Very-early and early maturing hybrids included 'Dekalb 372' (88 day maturity), 'Pioneer brand 3751' (97 day maturity), 'DPL 4393' (100 day maturity), 'AgraTech 575' (103 day maturity), 'Pioneer brand 3563' (103 day maturity), and 'Asgrow RX623' (105 day maturity). Three standard medium to late maturing hybrids, 'DynaGro 5510' (112 day maturity), 'DPL G-4666' (116 day maturity), and 'Pioneer brand 3165' (123 day maturity) were also evaluated. Planting dates were March 7 and April 15, 1994 and March 13 and April 17, 1995. Seeding rates were about 28,000 seed/A. Tests were not irrigated. All recommended cultural practices were followed (Mascagni and Burns, 1995).

Silking dates were recorded as the date when approximately 50% of the plants were silking. Hybrids were regarded as physiologically mature when about 75% of kernels in the middle portion of the ear had developed a black layer. Date of 20% grain moisture was determined by monitoring grain moisture dry-down. Grain yield was collected from two rows. Plots were harvested when grain moisture reached approximately 18% and yields were adjusted to 15.5% grain moisture.

The experimental design was a randomized complete block with a split plot arrangement of treatments. Planting dates were main plots and hybrids split plots. Four replications were used. Plots were four rows (40-in.) wide in 1994 and two rows (40-in.) wide in 1995. Analyses of variance were conducted using the GLM procedure of SAS (SAS, 1985).

RESULTS

Louisiana

Yields generally increased as hybrid maturity increased (Table 1). Highest yields occurred for the mid-April planting in 1994 and mid-March planting in 1995. The recommended planting window for north Louisiana is from March 10 to April 10. Across planting dates, 'Pioneer brand 3563' (103 day maturity) and 'Asgrow RX623' (105 day maturity) were competitive in yield performance with the standard, later-maturing hybrids, 'DynaGro 5510', 'DPL G-4666', and 'Pioneer brand 3165'.

As expected, dates to mid-silk, physiological maturity, and 20% grain moisture increased as maturity increased (Tables 2 and 3). Relative differences in maturity among hybrids were similar between planting dates each year. 'Pioneer brand 3563' reached 20% grain moisture 15 and 16 days earlier than 'Pioneer brand 3165' at the mid-

March and mid-April, 1994 planting dates, respectively. In 1995, the relative differences were 14 and 13 days for the same hybrids and similar planting dates.

The data indicates that hybrids with approximately 105 day maturity may compete with the standard, later-maturing hybrids. The earliest hybrids currently recommended in Louisiana mature in about 110 days. Other advantages for the early hybrids include early harvest, higher prices, less conflict with other cropping systems, and less risk from late summer storms. However, there are some potential problems with early hybrids. The early hybrids evaluated in this test were developed for the upper cornbelt. In that region, early-maturing hybrids are required because of the short growing season. One of the traits that enhance early harvest and quick grain drydown is loose or open husks. In the lower South, this trait may be detrimental to grain quality. Usually, as husk cover decreases, insect damage and, in some years, aflatoxin accumulation increases.

Arkansas

Potential evapotranspiration was estimated (Anon., 1985; Duchon, 1986; Cahoon et al., 1990; and Smajstrla et al., 1984) for a corn maturing on June 25 (Fig. 1). The stored soil water plus the incidental rainfall is sufficient to meet these needs on most years. Thus, we have a climatic as well as soil niche for these short season cultivars. If they matured around the time that wheat currently is harvested, they would avoid most droughts that occur in the region.

Corn is normally planted on a 38 in. bed in Arkansas. Since most crop land has slopes of less than 1%, planting on beds is done primarily to provide micro relief for surface drainage but it also provides a slightly faster soil warming. When we began to plant corn with a drill on a flat seedbed, the fact that bedded planting also controls traffic patterns became immediately obvious. The area of soil compacted by the trips used in land preparation, planting, fertilizer application, and pesticide applications is shown graphically in Fig. 2. These zones of high traffic were very easily identified in subsequent plant growth and survival. The corn growing in a wheel track was severely stunted while nearby plants (as close as 6 in.) in a non-compacted area grew normally. At the 4 to 6 leaf stage, the “normal” corn was two to four times taller. If the wheel track had depressions or natural depressions occurred where water stood more than two days following a rain, the stand tended to be lost and surviving plants were very yellow, indicating N deficiency.

During the late winter and early spring, the soil can be very moist and, as a result, easily compacted. Trying to prepare a seedbed and plant early on a flat seedbed resulted in areas of compaction. There are almost always periods of wet weather in late March, April, and early May that will cause standing water for several days in soil surface depressions. We feel that we need to address this situation by going to a stale seedbed that has corrugations every 38 in. for drainage. These corrugations will also serve to provide guidance for controlling the traffic patterns.

In applying nitrogen fertilizer, previous experience has shown that we get no damage to seedlings if the preplant N rate is kept at 50 lbs. or less per acre. This translates into 150 to 250 lbs. per acre that needs to be applied post-emergence, usually near the 6 to 8 leaf growth stage. Having aerially applied dry urea on corn near silking at a rate of 30 lbs. of N per acre with no problem, we anticipated no problems with broadcasting N over the top of the crop. However, the rates of N that were used in the post-emergence applications in all tests resulted in 100% leaf burn in both corn and grain sorghum, and there was some severe stalk burn where leaf collars were wrapped around the stalk.

Under dryland conditions at Pine Tree on the layered Calloway soil, the stored soil water was exhausted by early July, and all the leaves on the plants turned brown within 5 days. The grain sorghum planted next to the corn survived and produced a yield. With the loss of the crop canopy in early July and the presence of abundant N, weeds grew profusely. There were heavy infestations of morningglory, cocklebur, pigweed, and grasses. These weeds may necessitate a pre-harvest application of a desiccant.

Even though mistakes and production problems were encountered, ‘Cargill 2427’ at 60,000 plants per acre and fertilized with 300 lbs. of N per acre produced 102 bushels per acre yield in the irrigated test at Pine Tree. Plant populations differed with varieties in their influence on yield (Table 4). The corn tests at Keiser and the dryland test at Pine Tree were not harvested for grain yield.

In an effort to avoid some of the problems encountered with drainage, fertilizer leaf burn, and traffic, future research will include a planting and fertilization scheme as shown in Fig. 3. For producers, this planting scheme is usually accomplished with an 8-row, 38 in. toolbar that is configured with three 19 in. rows under the tractor, two 38 in. wheel track middles, and five 19 in. rows on the outside of the wheel tracks.

CONCLUSIONS

There appears to be a niche in the South for ultra-short season corn. The development of suitable varieties could result in consistent desirable yields, and a chance to miss some weather related problems concerning quality, such as aflatoxin. An earlier harvest could mean better grain prices, and may present the possibility of double-cropping with soybeans. However, more research is needed regarding production systems in relation to these cultivars.

ACKNOWLEDGMENTS

Cargill, Pioneer, Delta & Pine Land, DeKalb, Asgrow

REFERENCES

Anon. 1985. Climatic summaries for selected sites, 1951-1980. Climatography of the United States No. 20.

Bruce, R. R., J. L. Chesness, T. C. Keisling, J. E. Pallas, D. A. Smittle and A. W. Thomas. 1980. Irrigation of crops in the Southeastern United States: Principles and practice. U.S. Science and Education Administration, Agriculture Reviews and Manuals, Southern Series, No. 9.

Buol, S. W. (ed.) 1973. Soils of the southern states and Puerto Rico. Southern Cooperative Series Bulletin No. 174.

Denton, H. P., T. C . Keisling, G. W. Langdale, D. D. Tyler, J. E. Dean, and S. M. Dabney. 1995. Description of the Region and Subregions. *In* G. W. Langdale and W. C. Moldenhauer (eds.) Crop Residue Management to Reduce Erosion and Improve Soil Quality: Southeast. USDA-ARS. Conservation Res. Rep. No. 39. pp. 3-7.

Duchon, C. E. 1986. Corn yield predictions using climatology. J. of Climate and App. Meteorology. pp 581-590.

Cahoon, J., J. Ferguson, D. Edwards, and P. Tacker. 1990. A microcomputer-based irrigation scheduler for the humid mid-south region. Applied Eng. In Agric. Vol. 6, No. 3, pp 289-295. ASAE.

Hanway, J. J. 1971. How a corn plant develops. Iowa State University of Science and Technology Cooperative Extension Services. Spec. Rep. No. 48.

Heatherley, L. G. 1999. Early soybean production system (ESPS). *In* L. G. Heatherley and H. F. Hodges (eds.) Soybean production in the Midsouth. pp. 103-118.

Keisling, T. C., G. W. Langdale, and D. D. Tyler. 1995. Effects of Surface Residue on the Conservation, Availability, and Use of Water. *In* G. W. Langdale and W. C. Moldenhauer (eds.) Crop Residue Management to Reduce Erosion and Improve Soil Quality: Southeast USDA-ARS. Conservation Res. Rep. No 39 pp 10-11.

Langdale, G. W., T. C. Keisling, D. D. Tyler, S. M. Dabney, 1995a. Interactions of surface residues with soil and climate. *In* G. W. Langdale and W. C. Moldenhauer (eds.) Crop Residue Management to Reduce Erosion and Improve Soil Quality: Southeast. USDA-ARS. Conservation Res. Rep. No. 39 pp 10.

Langdale, G. W., T. C. Keisling, D. D. Tyler, J. E. Dean, and S. M. Dabney. 1995b. Description of surface-residue tillage systems in use. *In* G. W. Langdale and W. C. Moldenhauer(eds.) Crop Residue Management to Reduce Erosion and Improve Soil Quality: Southeast. USDA-ARS. Conservation Res. Rep. No. 39 pp 8-9.

Mascagni, H.J., Jr. and D.R. Burns. 1995. Performance of early maturity corn hybrids in North Louisiana. Louisiana Agriculture 38(4):11-12.

SAS Institute, Inc. 1985. SAS/STAT guide for personal computers. SAS Institute, Inc., Cary, NC.

Smajstrla, A. G., G. A. Clark, and S. F. Shih. 1984. Comparison of potential evapotranspiration calculation methods in a humid region. ASAE Paper No. 84-2010. Presented at the 1984 summer meeting American Society of Agricultural Engineers, Knoxville, TN.

Table 1. Influence of Planting Date on Yield Performance of 12 Hybrids on Sharkey Clay at St. Joseph, La, 1994 and 1995.

Hybrid	1994		1995	
	March 7	April 15	March 13	April 17
		bu/A		
Dekalb 372 (88)[1]	99	134	71	66
Pioneer 3751 (97)	129	185	109	76
DPL 4393 (100)	151	161	92	83
Agra Tech 575 (103)	94	123	94	82
Pioneed 3563 (103)	155	180	118	122
Asgrow RX623(105)	156	172	111	95
Dyna Gro 5510 (110)	153	192	125	104
DPL G-4666 (115)	160	170	121	90
Pioneer 3165 (123)	144	161	129	79
LSD (0.05) :				
Planting date (PD)	11		5	
Hybrid (H)	14		12	
PD X H	NS		17	

[1]Maturity as defined by the seed company.

Table 2. Influence of Planting Date on Date of Mid-silk, Physiological Maturity[1], and 20% Grain Moisture for 12 Hybrids on Sharkey Clay at St. Joseph in 1994.

Planting Date	Hybrid	Mild-Silk	Physiological Maturity	20% Grain Moisture
March 7	Dekalb 372	May 13	June 29	July 6
	Pioneer 3751	May 14	June 30	July 14
	DPL 4393	May 16	July 2	July16
	AgraTech 575	May 20	July 7	July 15
	Pioneer 3563	May 18	June 29	July 16
	Asgrow RX623	May 18	July 1	July 18
	DynaGro 5510	May19	July 9	July24
	DPL G-4666	May 23	July 10	June 27
	Pioneer 3165	May 25	July 11	July 31
April 15	Dekalb 372	June 3	July 19	July 27
	Pioneer 3751	June 5	July 21	August 1
	DPL 4393	June 10	July 24	August 6
	AgraTech 575	June 10	July 24	August 2
	Pioneer 3563	June 10	July 18	August 4
	Asgrow RX623	June 9	July 23	August 6
	DynaGro 5510	June 10	July 28	August 14
	DPL G-4666	June 13	July 31	August 17

	Pioneer 3165	June 15	August 1	August 20

[1]Hanway, 1971.

Table 3. Influence of Planting Date on Date of Mid-silk, Physiological Maturity, and 20% Grain Moisture for 12 Hybrids on Sharkey Clay at St. Joseph in 1995.

Planting Date	Hybrid	Milk-Silk	Physiological Maturity	20% Grain moisture
March 13	Dekalb 372	May 20	July 8	July 21
	Pioneer 3751	May 16	July 4	July 16
	DPL 4393	May 18	July 4	July 16
	AgraTech 575	May 22	July 9	July 18
	Pioneer 3563	May 19	July 2	July 16
	Asgrow RX623	May 19	July 5	July 16
	DynaGro 5510	May 20	July 8	July 21
	DPL G-4666	May 24	July 13	June 23
	Pioneer 3165	May 26	July 17	July 30
April 17	Dekalb 372	June 5	July 22	August 1
	Pioneer 3751	June 6	July 24	August 2
	DPL 4393	June 10	July 25	August 7
	AgraTech 575	June 12	July 26	August 6
	Pioneer 3563	June 11	July 24	August 6
	Asgrow RX623	June 11	July 25	August 5
	DynaGro 5510	June 12	July 31	August 13
	DPL G-4666	June 16	August 1	August 15
	Pioneer 3165	June 17	August 5	August 19

Table 4. Corn Yield as Influenced by Plant Population and Cultivar at Pine Tree. 1998.

Cultivar	Plant population	Yield
	(000's/acre)	(bu/acre)
Cargill 1877	40	65
	60	43
Cargill 2427	40	69
	60	93

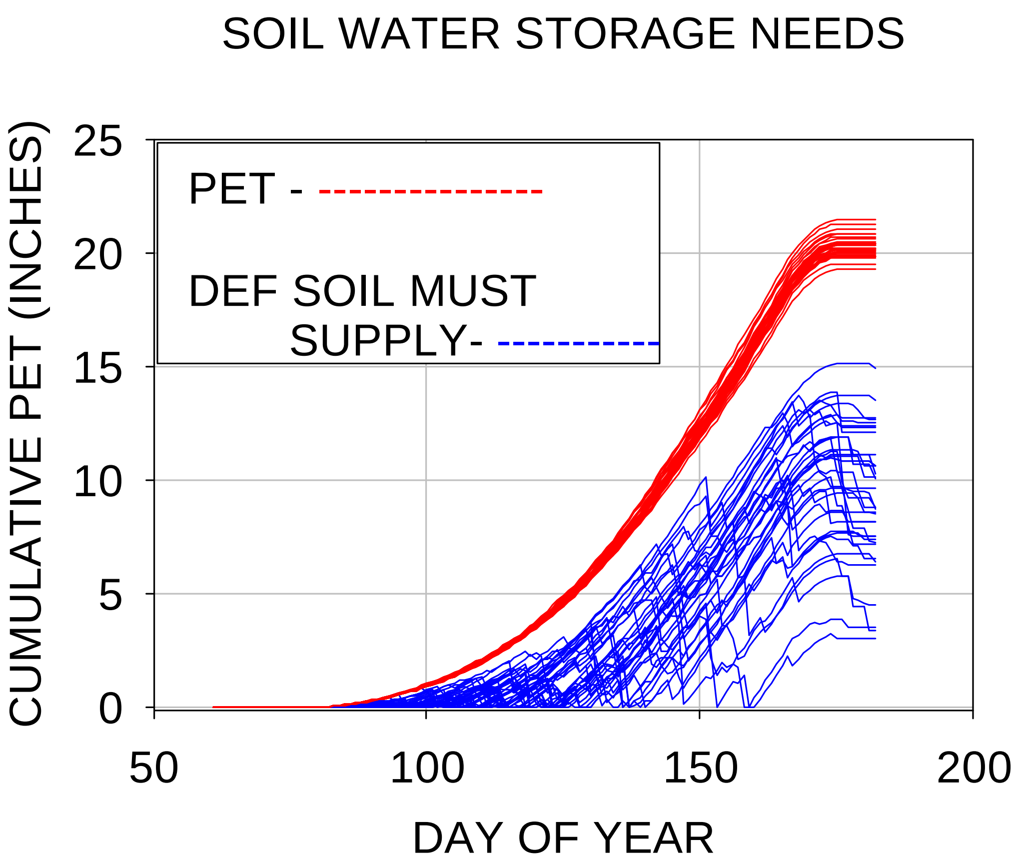


Fig. 1. Assessment of annual portion of evaporation that must be supplied by stored soil water to meet evapotranspiration demands, where PET refers to potential evaporation transpiration and DEF refers to moisture deficit that must be supplied by soil to meet PET.

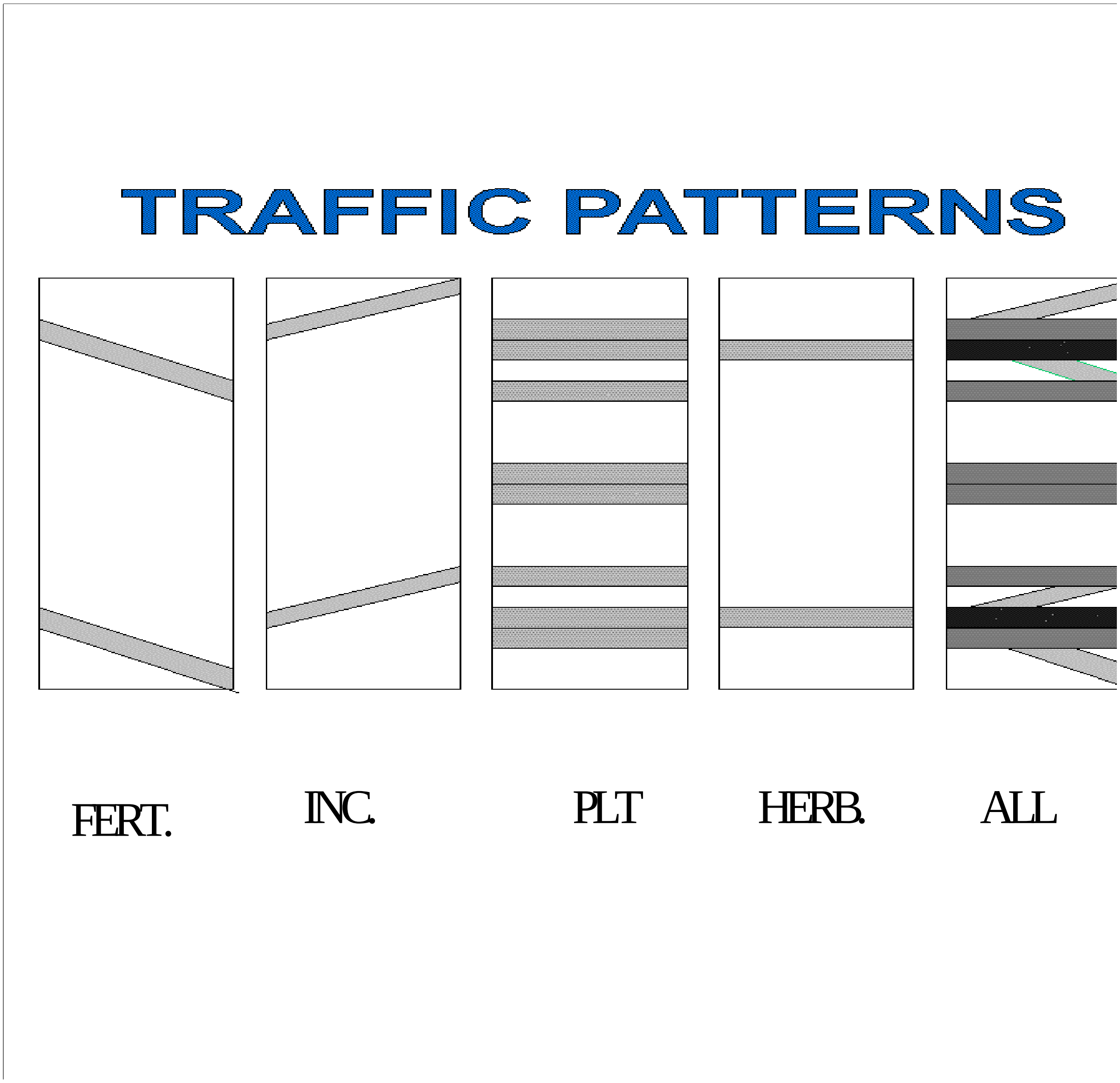


Fig. 2. Traffic patterns for 1998 at Keiser, AR.

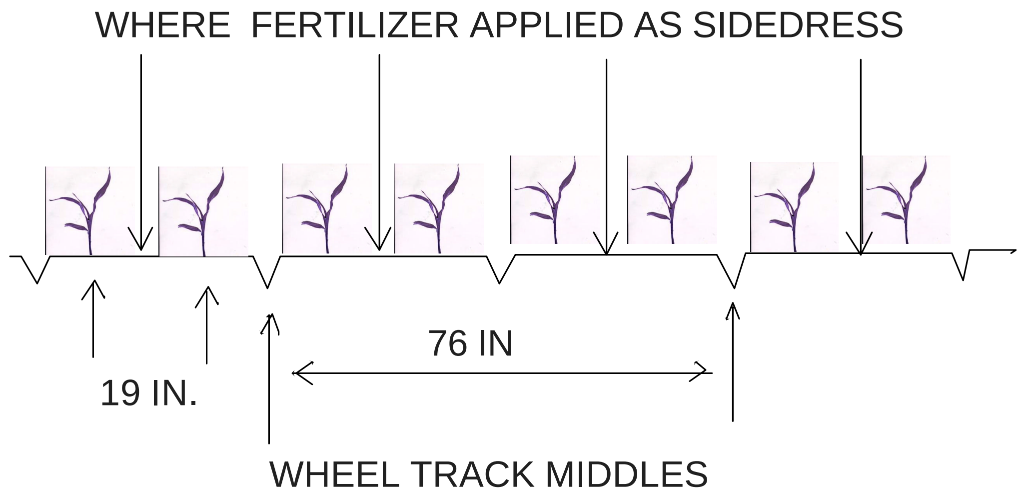


Fig. 3. Proposed seedbed preparation and planting pattern plan to alleviate surface drainage, soil compaction, and fertilizer burn problems.

IRRIGATED MULTIPLE-CROPPING USING BROILER LITTER IN CONSERVATION TILLAGE

G. J. Gascho[1], B. H. Baldree[1], T. B. Brenneman[2], G. H. Harris[1], D. R. Sumner[2], R. K. Hubbard[3], A. W. Johnson[3], P. L. Raymer[1], and W. W. Hanna[4]

AUTHORS: [1]Department Crop and Soil Science, [2]Department Plant Pathology, University of GA; [3] Nematodes, Weeds and Crops, and [4]Forage and Turf, USDA-ARS, Tifton, GA.Corresponding author: G. J. Gascho, Department of Crop and Soil Science, University of GA./CPES, P.O. Box 748, Tifton, GA.; E-mail gascho@tifton.cpes.peachnet.edu.

REFERENCE: J.E. Hook (ed.) *Proceedings of the 22nd Annual Southern Conservation Tillage Conference for Sustainable Agriculture.* Tiftton, GA. 6-8 July 1999. Georgia Agriculture Experiment Station Special Publication 95. Athens, GA.

Abstract. A double-cropped, irrigated, conservation-tilled, 3-year rotation was initiated at the Coastal Plain Experiment Station, Tifton, Georgia in 1996 and continues. The objectives are to determine the fertilization needed to balance nutrition supplied as surface-applied broiler litter and to determine the ability to produce high crop yields in conservation tillage. Cotton, peanut, and pearl millet for grain are planted in the summer, and wheat and canola are planted in the winter. Following cotton the plots are fallow. All summer and all winter crops are grown each year. The plots are arranged in split-plots with broiler litter rates of 0, 2, 4, and 6 ton/acre applied on the surface before each crop as the main plots and fluid fertilizer treatments as the split plots. High rates of broiler litter are rapidly increasing soil test P in the surface soil, signaling potential problems in the future. Litter application provided yield and value/acre increases for cotton, grain pearl millet, wheat, and canola. Any litter application was detrimental to peanut yield and grade. At a suggested rate of 2 ton litter/acre, gross returns of cotton increased by $66 or $35 /acre/year due to 10 gal/acre of 10-34-0 or 12-22-5 (2S) as starter fertilizers, respectively, but not consistently to three foliar KNO_3 applications; millet value increased only slightly due to starter application, but by $19 to $28 due to 40 lb N/acre as sidedressed urea ammonium nitrate solution; wheat value increased by $57/acre due to 40 lb N dribbled on 15 February, and canola value increased as much as $84/acre from two dribble applications of 40 lb N as UAN spaced at 45 and 90 days after emergence. Peanut responded only to application of a fungicide (flutolanil) in all 3 years of this rotation. These data should be useful in making recommendations for litter rates and economically efficient applications of fluid fertilizers following litter application in conservation tillage.

INTRODUCTION

Negative effects of water erosion are easy to find in the Coastal Plain of Georgia. Conservation tillage is badly needed. But, adoption of conservation tillage has been slow, mainly due to traditional thoughts of peanut farmers. The belief of those farmers was that the soil must be thoroughly mixed and be fluffy for subsurface development of peanuts and deep-turning with a moldboard plow buries surface debris, helping to reduce the incidence of southern stem rot (white mold) due to the removal of a food source for the soilborne fungal pathogens. Therefore the moldboard plow has been the tillage implement of choice. Since peanut has been the main cash crop and farmers have heavy investments in expensive large tractors and deep tillage implements, tillage for most crops tended to be by the conventional method with the moldboard plow. Recently, tillage experiments have shown that peanut yield and grade is as high in conservation (strip) tillage as for the conventional method (Hook and Thomas, 1998; Gooden, 1998). Nonirrigated strip-till with subsoiling in three consecutive drought years yielded 1642 lb peanut/acre in comparison to 1554 lb for moldboard tillage (Hook and Thomas, 1998). However, net returns were slightly less for the stip-till with subsoiling as the extra costs for weed control exceeded the costs for conventional tillage. Farmers are accepting the strip tillage method due to economics of time and labor. Farmer experience in the short-term has been generally good. However, there remains concern for the practice over the long-term due both to control of perennial weed species and to the supposed inability to get plant nutrients into the root zone when they must be applied on the surface with minimal opportunity for incorporation. Supplying calcium needed for peanut pod development is a special concern in that regard.

The large broiler industry is expanding rapidly and data released in January 1999 indicate that Georgia is the number one producer of broilers in the nation, surpassing Arkansas for the first time in 1998. Previously, the great bulk of broilers were produced in north Georgia. But, nearly all of the current expansion is in the Coastal Plain. Presently, there are approximately 2000 broiler houses in the Coastal Plain and that number could double in the next 5 years. Each broiler house results in approximately 150 tons of litter/year. One important reason for the expansion in south Georgia is that the Coastal Plain has abundant crop land for disposal and utilization of the litter. Such is not the case in north Georgia. Voluminous literature is available to indicate the benefits of nutrients in broiler litter for certain crops, such as corn. But, corn acreage has decreased in the area due to low quality and low profitability. It is apparent that applications of broiler litter will be made on land to be planted to peanuts and cotton, the main cash crops in the Coastal Plain. Benefits on cotton are not expected to be as great as for corn, in fact over application is expected to result in excessive vegetative (rank) growth. Therefore, N-bearing materials, such as poultry litter must be applied with care. Benefits to peanut will be little and the risk of increased disease due to excessive vine growth are expected to be great. In addition, poultry litter does not contain nutrients which will result in a balanced nutritional condition for most crops. Indiscriminate application will lead to serious nutritional imbalances. The flexibility of fluid fertilizer compositions and ease of application make them well poised to be of value in providing balanced nutrition.

Due to increasing demand for cotton and the elimination of the boll weevil, making insect control much less costly, the cotton acreage has expanded very rapidly in the Coastal Plain. Cotton acreage in the region has more than quadrupled in the past 4 years and is currently 1.4 million acres, surpassing the acreage and value of the peanut crop, which has been the crop with the greatest value in the State for many years. Wheat is the greatest value winter crop and is easily double-cropped. Canola and pearl millet, for grain, are promising new crops. At least a 3-year rotation is recommended for peanut and canola to minimize soil-borne diseases.

The goal of the research is to predict supplemental fertilizer needs in a conservation-tilled intensive cropping system receiving variable rates of broiler litter and satisfy those needs with starter-, foliar-, and sidedress-applications of fluid fertilizers.

MATERIALS AND METHODS

An experiment was initiated on the Coastal Plain Experiment Station in Tifton, GA on a Tifton loamy sand, (Plinthic Kandiudult) in Feb. 1996. Former crops were cotton proceeded by wheat. The experiment is a 3-year irrigated double-cropping system with each crop grown each year (Gascho et al., 1997; Gascho and Brenneman, 1998). The sequence of crops in a cycle is cotton, fallow, peanut, canola, pearl millet, and wheat. Within the three cycles grown each year there are four broiler litter rates of 0, 2, 4, and 6 ton/acre as the main plots of a split-plot arrangement of a randomized complete block design. Mean nutrient analysis of the litter is supplied in Table 1.

Within each litter rate, six treatments are included to attempt to balance plant nutrition for top yield, grade and profitability. For the winter crops of canola and wheat, the split-plots are timing and rates of N as surface-dribbled urea ammonium nitrate (UAN, Table 3). For cotton, peanuts, and pearl millet the basic treatments include: 1. nothing additional, 2. 10 gal/acre of 10-34-0 starter, and 3. 10 gal/acre of 8-22-5(2S) starter. Starters are applied 2 inches below and 2 inches to the side of the seed. For cotton, sprays with potassium nitrate during fruit development are applied at first bloom, 2 weeks later and 4 weeks later. The sprays are in 20 gal water/acre at 10 lb KNO_3/acre. For peanut, control for white mold and limb rot are included by either applying or not applying flutolanil (in two applications for each starter fertilizer treatment). Pearl millet plots either receive or do not receive an extra 50 lb/acre N as sidedressed 30-0-0 for each starter fertilizer treatment. There are 4 replications for a total of 288 plots.

The mold board plow was not used in this experiment and surface tillage has been eliminated gradually in the 3 years of the experiment reported. Prior to the summer crops in 1996 the site was chisel-plowed to depth of 10 inches. Litter was incorporated 4 inches deep with herbicide (ethylfluralin at 1 qt./acre for peanut, pendimethalin at 1.5 pt./acre and fluometuron at 1.5 qt./acre for cotton, and propazine at 2 qt./acre for pearl millet) with a rototiller. In the fall of 1996 and 1997 plots to be planted to wheat and canola were subsoiled to 18 inches with three shanks/6 ft. bed. Discing to a depth of 4 inches was also required to incorporate litter and herbicide (trifluralin at 1 pt./acre for canola). In the spring of 1997 and 1998 all plots were paratilled, and all vegetation was killed with glyphosate (1 qt./acre) 2 weeks prior to planting summer crops using strip tillage with subsoiling. At planting, pendimethalin was broadcast (1.5 pints/acre) for peanut. Pendimethalin (1.5 pt./acre) and fluometuron (1.5 qt./acre) were broadcast for cotton and propazine was broadcast (2 qt./acre) for pearl millet. Winter crops planted in 1998 were no-tilled using a Tye planter without using preplant herbicide following paratilling.

Soil samples were obtained in main plots in depth increments of 0-6 , 6-12 , 12-18, 18-24, and 24-30 inches each winter to evaluate changes in nutrient elements with soil depth as affected by litter rate. Only the results for changes of Mehlich-1 P in the top 6 inches are presented here, as changes below the top increment have been minimal to date.

All data were summarized by analysis of variance using the split-plot method. Means for the subplots were separated by LSD at P=0.10.

In this article, we emphasize yield and economic gains from the treatments. For peanut, the value/acre was established by a formula based on yield and grade. For other crops, value is obtained by the mean price of the commodity over the time it was grown in the project. The market price of corn was used to calculate the value of pearl millet grain, since no market is established and the feed value is similar to corn. Value of the change made by fertilizer application was analyzed at the rate of broiler litter currently recommended (not all official at this time) by the University of Georgia Extension Service.

RESULTS AND DISCUSSION

For all crops, except peanut, growth and yield were increased by broiler litter application. In most crops and years, the increased growth was only observed to the 2 or 4 ton rates. Increased peanut growth and development differences were observed to the 2 ton rate in 1996, but not in 1997 or 1998.

Soil test P (Mehlich-1) in the top 6 inches increased in a nearly linear manner over a 2-year period due to broiler litter application rate (Fig. 1). Increases of the magnitude of 32 ppm in 2 years by application of the 6 ton rate (total of 24 ton/acre for the four crops grown during that period) are not acceptable from an environmental standpoint. If high rates of broiler litter are applied, soil P levels will increase to very high levels in a few years, thus defeating one of the prime reasons for locating new broiler houses in the coastal plain of Georgia rather than in the piedmont area, where soil P is already very high by the levels established by the Soil Test Laboratory of the University of Georgia Cooperative Extension Service (Plank, 1986) due to litter application.
For both production and environmental reasons, the Georgia Extension Service is now recommending that litter be applied at 2 ton/acre/crop. Soil test K was depleted for all litter rates, but not to the low level (data not shown). The depletion of soil test K increased slightly as litter rate increased. Broiler litter does not contain adequate K. With time, K will be required to produce good crops, once soil test K is reduced to a low level. Both P and K contents of broiler litter are examples of the need to balance crop nutrition with additional fertilizers where litter is applied.

Analysis of variance by the split-plot randomized complete block method indicates many significant responses in yield for litter application and fluid fertilizer treatments (Table 2). In many analysis, the interaction of broiler litter rate and fluid fertilizer treatment was also significant. The main effects of broiler litter rate are provided in Fig. 2 to 6 for the crops included in the rotation.

Cotton yields were 2 to 2.5 greater than the State average in all 3 years of the experiment (Fig. 2). The main reason for the high yields was irrigation, but broiler litter also had a large positive effect on yield. The effect was positive to the 4 ton rate in 1996 and 1997 and only to the 2 ton rate in 1998. The different response in 1998 was possibly due to the fact that soil N and P levels were increasing to excessive levels by repeat applications of broiler litter. Following application of litter to the 1998 cotton, a total of 20 tons had been applied at the 4 ton rate and 30 tons at the 6 ton rate. These results support the recommendation of only applying 2 ton/acre/crop. Over all litter rates, analysis by LSD at P=0.1 indicate that cotton yields were increased by starter fertilizer applications in 1996 and 1997, but not in 1998. Over all, three foliar applications of KNO_3 did not produce significantly more cotton yield. That result may have been different if soil test K were at a "low" level (0 to 35 mg/kg). For the recommended rate of 2 ton litter/acre gross economic increases were not consistent over the 3 years of cotton in the rotation (Table 4). Mean increases of 66 and \$33/acre/year were attained from 10-34-0 and 12-22-5 (2S) starters, respectively. Economic data for the application of foliar KNO_3 at the 2 ton litter rate were variable and inconclusive.

Peanut data are presented as value/acre (Fig.3, Tables 3 and 4). The largest component of value/acre was yield with adjustments due to grade using the USDA Peanut Loan Schedule. In all 3 years, peanut value/acre was reduced greatly by application of broiler litter, regardless of the rate (Fig. 3). That result supports our current recommendation that no fertilizer need be applied to peanuts when soil tests are medium or greater. Consideration is being given to also recommending against the application of any broiler litter for peanut. Peanut has long been known to produce best when residual fertility is supplied (Gascho and Davis, 1994). In none of the 3 years of peanuts did starter fertilizers treatments increase value of peanut when all litter rates were considered (Table 3), but application of flutolanil fungicide in addition to application of normal fungicide for leaf spot provided much increased value. At the proposed recommended rate of broiler litter (none), there appears little justification for farmers to make starter applications for peanut (Table 4).

Pearl millet for grain showed responses to litter to the 6 ton rate in 1996 and to the 2 ton rate in 1997 and 1998 (Fig. 4). Although this crop is not established on many acres at this time, it seems reasonable from the data that a recommended rate would be 2 ton/acre. Over all rates of litter, starter fertilizers did not significantly increase yield, but sidedressing with 50 lb N/acre as UAN did increased yield (Table 3). At a potential recommended rate of litter of 2 ton/acre, 50 lb N/acre provided 19 to \$28/acre more gross revenue (Table 4).

Wheat yield was low in 1997 due to late detected disease problems and but higher in 1998. Wheat responded well to broiler litter (Fig. 5) and to sidedressed UAN in 1998 (Tables 3 and 4). Response to litter was to the 4 and 6 ton rates for the two years completed (Fig. 5). Over all litter rates, top dress dribble application of 40 to 60 lb N as UAN on about 15 February (early) produced the greatest yield (Table 3). There appeared to a penalty for late application (15 March) and no additional response to two applications. At the 2 ton litter rate, approximately $60/acre gross revenue was averaged by application of 40-60 lb N early (Table 4).

Canola yields above state averages were produced on the plots in 1997 and 1998. Yields responded positively to litter application, peaking at the 4 ton and 6 ton rates for 1997 and 1998, respectively (Fig. 6). Responses to top dress dribble UAN were also significant, but different than for wheat (Table 3). Late application of the UAN (90 days after emergence(DAE)) resulted in greater response than early application (45 DAE). However, the “early” application on wheat and the “late” application on canola arrived at nearly the same calender date, possibly suggesting that specific weather conditions may have been important in the observed responses. At a 2-ton litter rate, our data suggest profitable responses to dribble applications of UAN on canola. The gross responses averaged $63/acre/year for a single application of 40 lb N at 90 DAE and $84/acre/year when two applications of 40 lb N were made.

REFERENCES

Gascho, G. J. and J. G. Davis. 1994. Mineral nutrition. Chap. 7, pp. 214-254 *In* J. Smartt (ed.) The Groundnut Crop, Chapman and Hall, London

Gascho, G. J., D. Balaguravaiah, and T. B. Brenneman. 1997. Fluid fertilizer as starter-, foliar-, and Sidedress-applications in an intensive crop rotation. Fluid Fertilizer Forum Proc. pp.186-187.

Gascho, G. J. and T. B. Brenneman. 1998. Fluid fertilizer as starter-, foliar-, and Sidedress-applications in an intensive crop rotation. Fluid Fertilizer Forum Proc. pp.114-124.

Gooden, D. L., 1998. Tobacco and peanut cropping systems. CRIS project SC01671, Accession No. 0175222.

Hook, J. E. and D. L. Thomas. 1998. Soil and water management for production agriculture in the Georgia Coastal Plain. CRIS project GEO00156, Accession No. 0163948.

Plank, C. O., 1989. Soil test handbook for Georgia. Georgia Cooperative Extension Service, University of Georgia, Athens, GA.

Table 1. Mean nutrient analysis of broiler litter.

Nutrient	Content	Nutrient	Content
	lb/ton		lb/ton
N	48	Fe	4
P_2O_5	46	Al	5
K_2O	34	Mn	0.6
Ca	25	B	0.04
Mg	6	Cu	0.4
		Zn	0.5

Table 2. Analysis of variance for yields†

	Cotton			Peanut			Pearl Millet		
Source	96	97	98	96	97	98	96	97	98
Broiler litter rate	**	*	**	NS	‡	NS	NS	**	**
Fertilizer treatment	NS	NS	NS	**	*	**	‡	NS	*
Interaction	NS	NS	NS	NS	‡	*	NS	**	NS

	Wheat		Canola	
Source	97	98	97	98
Broiler litter rate	**	**	**	**
Fertilizer treatment	**	**	**	**
Interaction	**	**	**	**

† Significance by split-plot method with **, *, ‡, and NS = significant differences at P = 0.01, 0.05, 0.10, or not significant at P = 0.10, respectively.

Table 3. Effects of fertilizer subplots on crop yields and peanut value.

Cotton (lb lint/acre)	1996	1997	1998
No Starter, No KNO_3	1114 b[†]	1120 b	982 a
No Starter, KNO_3	1182 ab	1175 ab	964 a
10-34-0, No KNO_3	1192 a	1228 a	962 a
10-34-0, KNO_3	1204 a	1132 ab	914 a
12-22-5, No KNO_3	1169 ab	1191 ab	994 a
12-22-5, KNO_3	1210 a	1164 ab	1021 a
Peanut value ($/acre)	1996	1997	1998
No Starter, No Moncut	630 c	1028 bc	1300 bc
No Starter, Moncut	1070 a	1072 ab	1578 a
10-34-0, No Moncut	584 c	1023 bc	1355 b
10-34-0, Moncut	887 b	1149 a	1636 a
12-22-5, No Moncut	652 c	971 c	1217 c
12-22-5, Moncut	904 b	1101 ab	1509 a
Pearl millet grain (lb/acre)	1996	1997	1998
No Starter, No Fert. N	2239 c	2736 b	4244 b
No Starter, 50 lb N	2564 a	2927 ab	4286 ab
10-34-0, No Fert. N	2287 abc	2928 ab	3612 c
10-34-0, 50 lb N	2396 ab	3063 a	4385 ab
12-22-5, No Fert. N	2038 c	2940 ab	4009 bc
12-22-5, 50 lb N	2419 ab	3033 ab	4810 a
Wheat (bu/acre)		1997	1998
No Fert. N		18 bc	27 e
40 lb N 3/15		17 cd	36 d
40 lb N 2/15		24 a	42 bc
40 lb N 2/15 + 40 lb N 3/15		18 cd	45 ab
60 lb N 2/15		20 b	45 a
60 lb N 2/15 + 40 lb N 3/15		17 d	41 c
Canola (bu/acre)		1997	1998
No Fert. N		33 c	24 e
40 lb N @ 90 d		38 b	34 bc
40 lb N @ 45 d		35 c	29 d
40 lb N @ 45 d + 40 lb N @ 90 d		39 b	36 ab
60 lb N @ 45 d		39 b	32 c
60 lb N @ 45 d + 40 lb N @ 90 d		42 a	37 a

[†] Values are means of four litter rates and four replications. Values in a crop and column followed by a common letter are not significantly different by LSD at P = 0.10.

Table 4. Increase in yield or gross value due to fluid fertilzer application following two ton broiler litter for cotton, pearl millet, wheat and canola and no litter for peanut.

Cotton	1996	1997	1998	Means	
		----------lb lint/acre----------			$/acre
No Starter, KNO_3	22	21	0	14	10[†]
10-34-0, No KNO_3	54	168	69	97	66
10-34-0, KNO_3	149	176	-106	73	50
12-22-5, No KNO_3	58	311	25	131	89
12-22-5, KNO_3	105	171	58	111	75
Peanut value	1996	1997	1998	Means	
	----------$/acre----------				
No Starter, Moncut	469	133	481		361
10-34-0, No Moncut	48	-120	125		18
10-34-0, Moncut	249	220	514		328
12-22-5, No Moncut	47	-24	-171		-49
12-22-5, Moncut	156	6	484		215
Pearl millet grain	1996	1997	1998	Means	
		----------lb/acre----------			$/acre
No Starter, 50 lb N	384	-99	1195	493	22
10-34-0, No Fert. N	225	-48	-63	38	2
10-34-0, 50 lb N	-71	326	1022	426	19
12-22-5, No Fert. N	82	52	130	88	4
12-22-5, 50 lb N	624	-267	1542	633	28
Wheat		1997	1998	Means	
			----------bu/acre----------		$/acre
40 lb N 3/15		1	17	9	27
40 lb N 2/15		10	28	19	57
40 lb N 2/15 + 40 lb N		5	30	18	54
60 lb N 2/15		8	32	20	60
60 lb N 2/15 + 40 lb N		4	28	16	48
Canola		1997	1998	Means	
			----------bu/acre----------		$/acre
40 lb N @ 90 d		6	12	9	63
40 lb N @ 45 d		3	3	3	21
40 lb N @ 45 d + 40 lb		10	13	12	84
60 lb N @ 45 d		6	7	6	42
60 lb N @ 45 d + 40 lb		11	14	12	84

[†]Means $/acre figured using average prices for the years included: cotton lint =$0.68, Peanut by formula based on yield and grade, pearl millet based on corn @$2.50/bu, wheat @$3.00/bu and canola @$7.00/bu.

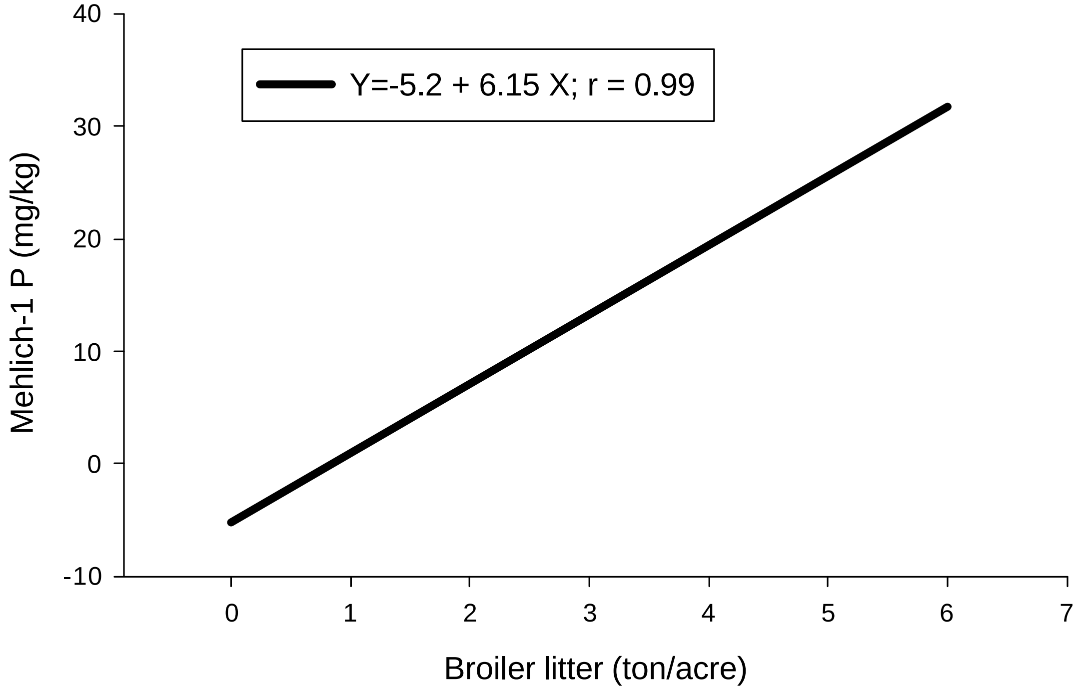


Fig. 1 Mehlich-1 soil P change in top 6 inches due to litter in a 2-year period from 1996 to 1998

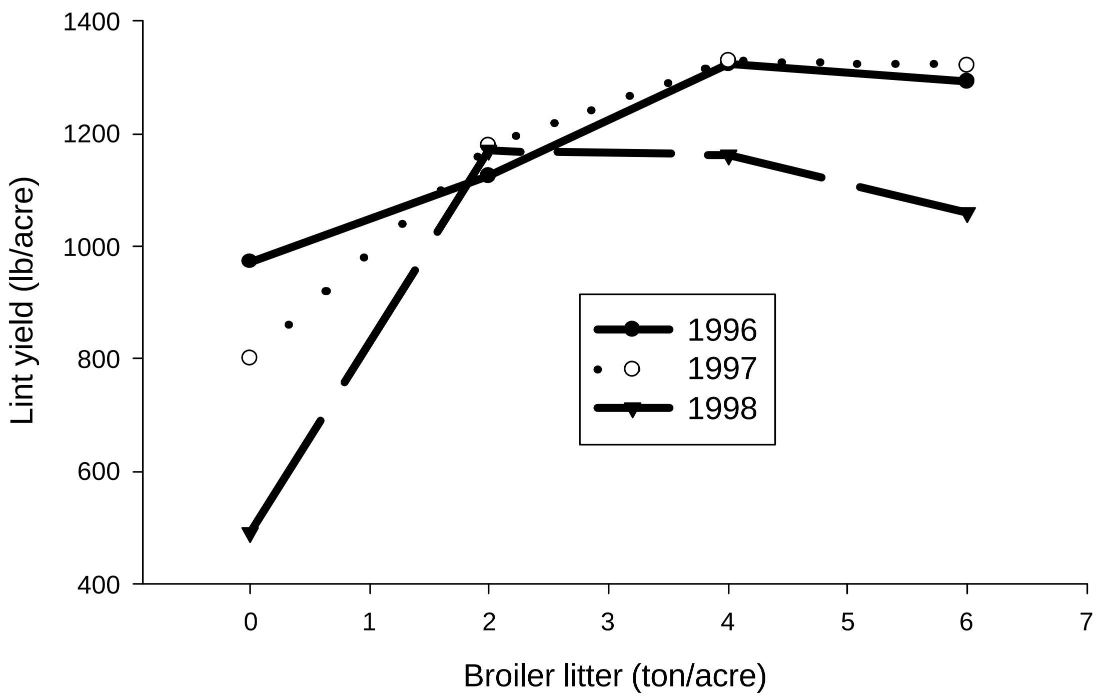


Fig. 2 Broiler litter effect on cotton lint yield, 1996-98

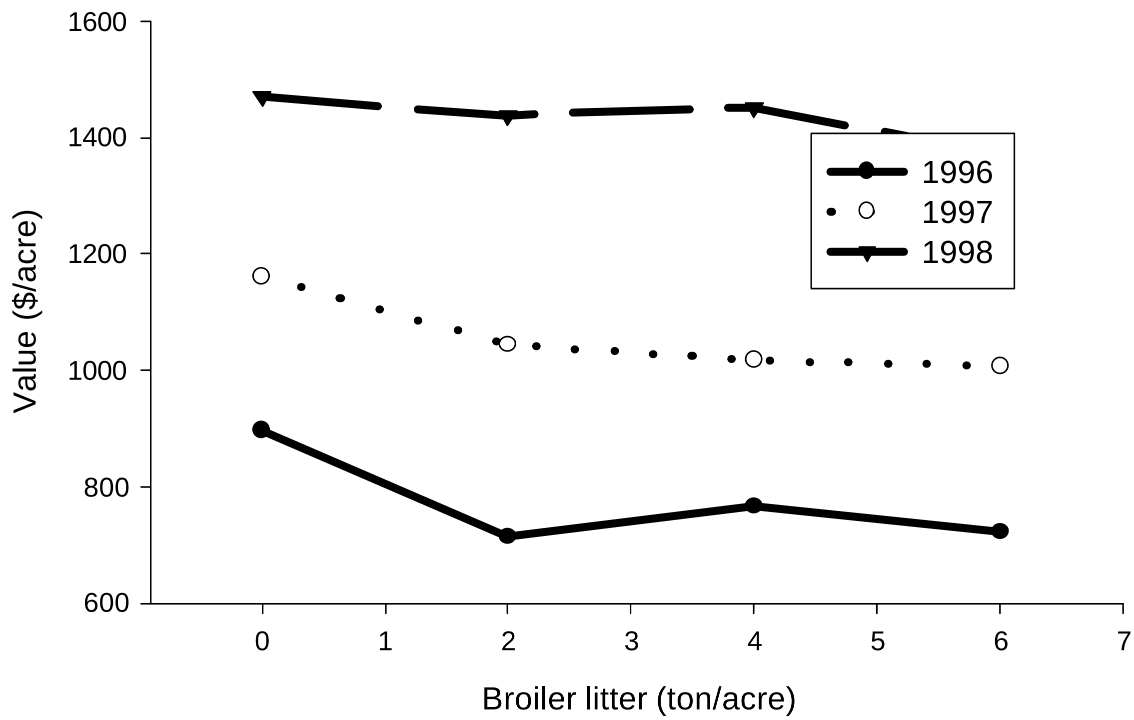


Fig. 3 Broiler litter effect on peanut value, 1996-98

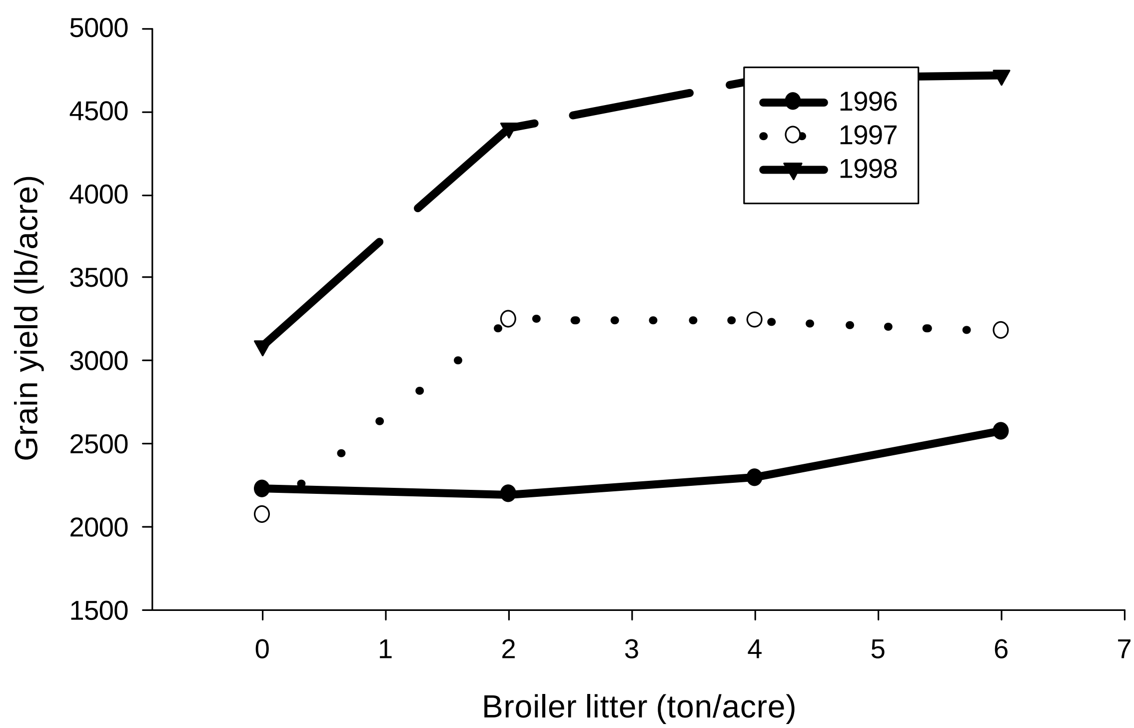


Fig. 4 Broiler litter effect on pearl millet grain yield, 1996-98

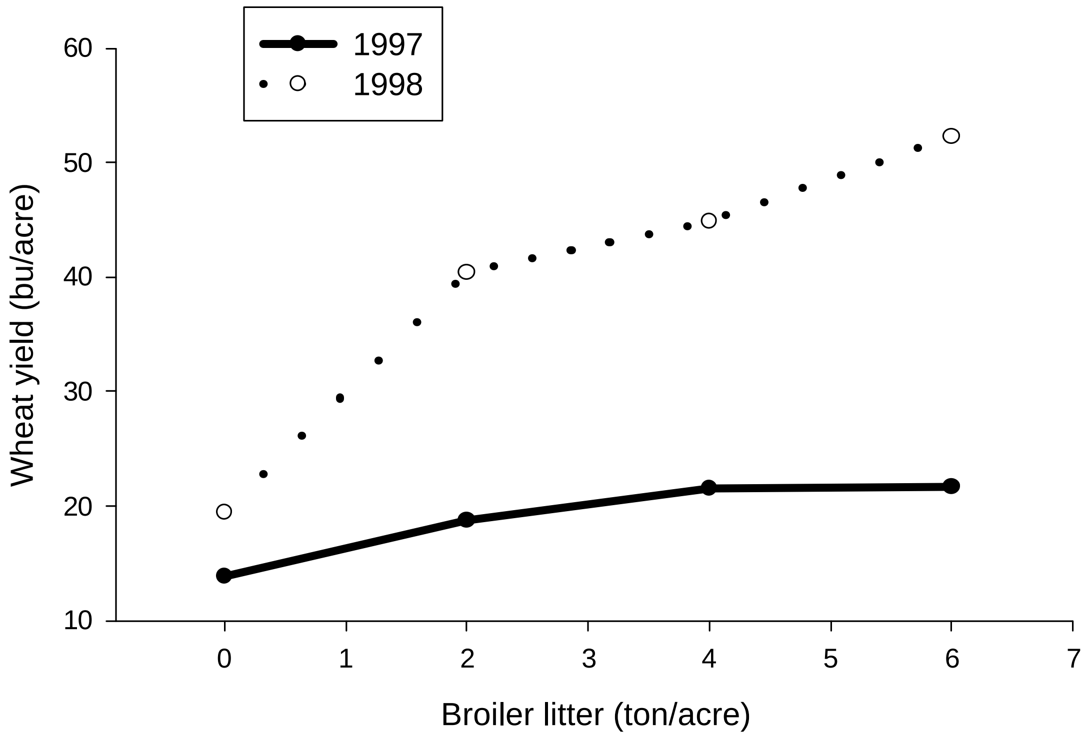


Fig. 5 Broiler litter effect on wheat yield. 1997 and 1998

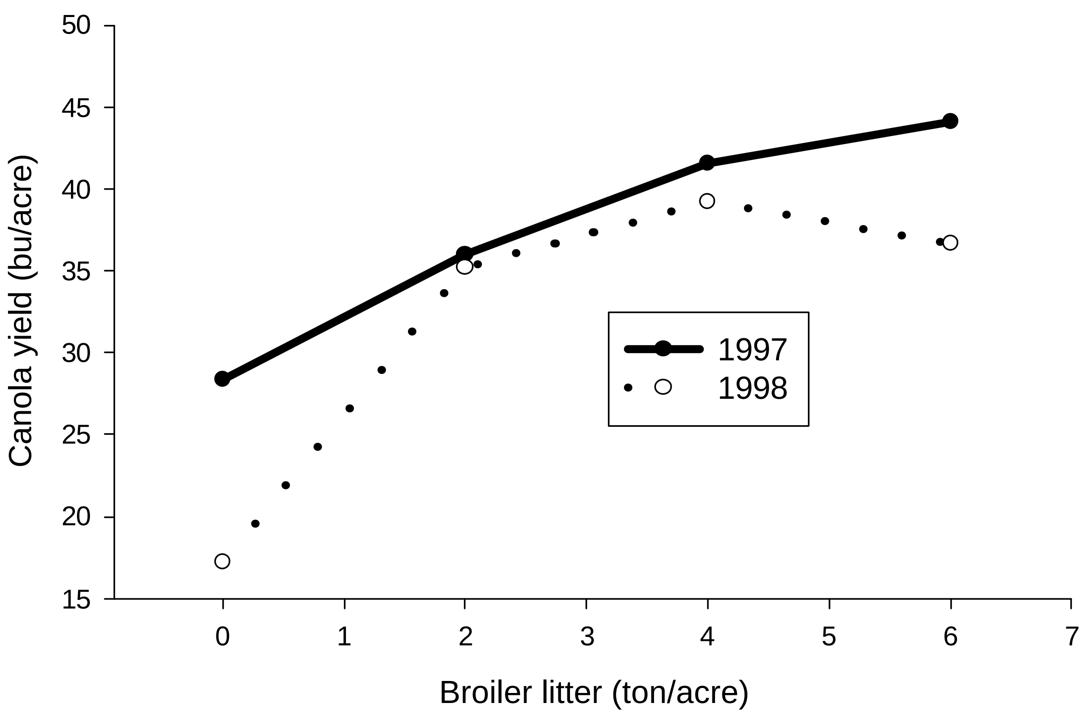


Fig. 6 Broiler litter effect on canola yield, 1997 and 1998